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SCIENCE AND SOCIAL EFFECTS: THREE FAILURES

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THE future of human enterprise is predictable in part only, and most often in terms of *if*. To increase our technological efficiency by 20 per cent., would permit us to pay off our national debt in a generation, *if* the corresponding net profits were not dissipated by multifarious waste or social inefficiency. Every proposal, fact, or condition has wrapped up in it the mystery of its contingent event, a mystery designated by *if*. One thing leads, commonly, to another that is not foreseen or expected.

This warning is essential at the beginning of an argument on the solid achievements of science (in fields of limited fact and experience) which tempt us to expect too much of social applications. "Science tells us" is a phrase of confidence to which we have all become habituated. This has its dangerous as well as its hopeful aspects. We have yet to prove that, in Wheeler's phrase, we are not just so many "juicy colloids bombinating through the cosmos."

There is a second warning to be observed at the outset. Conscious of the limits of forecast in human affairs, we are apt to overlook powers of forecast already won. How we came to develop or possess these powers is a fundamental question: the study of their origins will certainly reveal further possibilities, for we cannot suppose that we have done more than begin their development. The end is never *now*. To enlarge our powers in this field it will be necessary to *know* much more and also to intensify our imaginative and conceptual processes. It is equally important, perhaps, to see what hazards beset forecast in the social field. Perceiving a danger pointed out by science, what does society do about it?

It would be easy to compile a list of beneficial effects following upon the application of science to social problems. Beginning with public health measures, which are responsible for one of the chief triumphs of associative living, we could pass to comforts and conveniences, lifted burdens, widened horizons of knowledge and deeper intellectual satisfactions. Perhaps you expect me to provide such a list of triumphs, for this association is designed to demonstrate the solid human worth of science and give it wider dominion. But might it not prove equally useful, now and then, to analyze instances of social failures which were definitely forecast if the related science were neglected? I propose to describe three failures in at least one of which forecast has been fully verified. They relate to the hitherto unsolved problems of peacemaking, the decline of the oyster industry of Maryland and the destruction, with tragic human consequences, of certain tropical soils.

A distinguished member of one of the European delegations to the Peace Conference of Paris (1919) bade me goodbye with the remark, "I return home a deeply disappointed man. I came believing that through my science I could successfully support my country's claims and help win for it a dominating place in Europe." What he meant was that through his science he had acquired a systematized body of knowledge and an explicit and impressive terminology by the aid of which his national leaders might win advantages at the expense and to the disadvantage of neighbors. Science in my friend's case became advocacy for nationalistic aims: in short, it ceased to be science.

Clemenceau rejected science altogether. He had a severely practical view with respect to the political aims of 1919. Said he, "The appeal to abstract justice demands judges. France, England, America had bought with their blood the right to that high office. They could dictate forms of justice. . . . That is how civilizations progress." There were two fatal defects in his philosophy: Whose justice? What force should maintain it? Treaties must be made as best they can, almost *at moments*, whereas an ordered or scientific and humane society is a thing that must evolve over the years and with continuing trial, error, and revision.

We deceive ourselves if we think that just at the close of a victorious war we can improvise a Utopian peace. It was not done in 1919. Who has learned to do it in 1940? *There is no science of justice.* In fact, there are diametrically opposite opinions on and feelings about justice because the litigants are the judges. Science can tell us where a boundary should run to provide equality of *strategic* advantage to bordering states; it tells us where it should be drawn to distinguish *ethnic* differences; it discloses how states should be delimited to provide industrial *power* in proportion to population. It can not provide the political and moral bases for the optimum combination of these conflicting and disparate interests and conditions.

We shall make better progress in the next peace if we look for the faults of the world not in treaties but in the underlying and as-yet-unsolved problems with which men grapple who make the treaties. No treaty can leave everyone satisfied. This is not due to conflicting greeds only. It springs from cultural differences and commitments, from unequal resource inheritances, unequal aptitudes and powers, fear, ambition, propaganda. A Versailles does not solve problems arising from such diverse sources: it only rearranges the problems. Will the next peace treaty do more? Wisdom *evolves through time* like the rest of man's social and moral equipment. A war treaty is framed in an emotional atmosphere, and a coalition of victorious powers has a terribly hard time agreeing on terms among themselves, not to speak of agreement with the enemy. There is, in short, no well-understood and accepted substitute today for what Clemenceau called, in 1919, "dictated forms of justice." It is clearly unscientific to be forced to define and document world justice while fifteen million men are under arms.

Statesmen and politicians deal with feeling, prejudice, pride, in short, folk psychology about folk-lore. If they resort to scientific terms it is only to give feeling an appearance of solid underpinning. Newtonian principles and terms have often provided statesmen with a nomenclature "that seemed to exhale the odor of ultimate truth." Political gravitation, natural rights, invincible law, a scientific border, rule of propinquity, geographical claim, organic growth—all are terms of rationalization that have been employed by political leaders, adventurers, argufiers, military

chiefs, scholars. For example, all of them have been used, as Weinberg has shown in "Manifest Destiny," to give America a national thesis whose ultimate defense required nothing additional except an appeal to patriotism tinged with morality!

Beginning with Jefferson in 1806 and coming down to 1940, the changes have been rung upon the "scientific" proof of theses that have to do with economic doctrine, political programs and social objectives. At this moment the limits of disputed territorial claims to unoccupied spaces in the Arctic and the Antarctic follow meridians as if a logical quality were imparted to a claim by bounding it with imaginary lines that are familiar features upon the library globe and in "mathematical" geography. If *fairness* were the only recognizable basis of territorial claims and national "rights," then scientific methods might have nothing to do with boundaries. But *there is no science of fairness.* In general, that is fair between two peoples which is voluntarily and freely agreed to be fair under approximately equal conditions of knowledge. Science and fairness are often in happy and useful relation in the affairs of states: the important thing is that we have not made the relation inevitable or general.

Science should be indispensable in international affairs if only because it reduces the number and extent of areas in which feeling alone dominates, or national prestige, or political rivalry. Science deals not alone with assured fact but also with probabilities. For instance, it does not reveal at a moment of time exact knowledge about the total quantity of petroleum in the earth's crust and its geographical distribution; rather, it reveals a known or inferred quantity, the probabilities with respect to further discoveries of new fields, and the extent, efficiency and cost of existing recovery methods. Modern chemistry hints that the *amounts* in given categories of natural resources within national boundaries will take on new meanings in the light of further scientific progress. But no one can predict such changes in meaning, or announce the growth rates or *aptitudes* of the future population, or their relation to existing resources and future welfare with sufficient accuracy to provide a sure basis of national policy. Nor can we measure public spirit, the depth of appeal of tradition, the capacity to develop a united world program that demands nationalist sacrifice.

But what of the areas in which science may play a part? A single item in a series may be mentioned. As surely as night follows day, the problem of postwar production in the face of delayed industrial reemployment of discharged soldiers will tax the ingenuity and financial power of Western civilization. We can not talk of "gradual adjustment": A man may starve in less than a fortnight. Taxation and relief (or its substitute, war industries) have limits to which Europe is dangerously close. To stop war industries and *not* start a substitute is to invite disorder if not disaster. If peace were possible to-morrow, could the world afford to stop its war program without having a peace program ready for adoption?

Confronted with these difficulties ought not the power states to be about the business of creating new industries, surveying and appraising underdeveloped land that might provide not mere additions to world surpluses but support for largely self-contained economic units producing wanted exports, closing the gap between full productive power and our present deficient consumption? In these processes science is indispensable. It is ready to go. A sum equal to the cost of one battleship would give it enormously increased motive power. Reparations and armistice terms will not supply that motive power, nor will loans,

tariff adjustments, shipping pools and currency stabilization schemes supply it, helpful as some of these *arrangements* may be. What is wanted is something deep down, not an arrangement but an addition.

II

Before most readers of this article had entered the primary school, Professor W. K. Brooks of Johns Hopkins first fertilized oyster eggs artificially and began the study of the development of the oyster embryo. He was fond of saying that he had hatched from artificially fertilized eggs more oysters than there were inhabitants of the United States. From 1883–84 he served as oyster commissioner of the state of Maryland. He forecast with astonishing accuracy what President Gilman called the decline and fall of the oyster empire of the Chesapeake.

He was a trumpeting Gabriel when it came to social effects which he wished to correct: He heralded grave losses to everyone in Maryland (not merely to the dredgers, dealers, packers and carriers of oysters) if the destruction continued, and he declared the advantages to everyone in the state if human intelligence, industry and science were to supplement the bounty of nature. Instead of using intelligence, said he, we "snatch a slight tribute" from our natural store of bounty and pay no attention to the state of the water and the black bottom mud of the bay that have a vital relation to the biology of the oyster, thus using not a "hundredth part of our advantage."

Basing his argument upon an intimate knowledge of the oyster and upon the then existing state of the industry, he called attention to the lack of thorough surveys and maps of the oyster beds, surveys that might give an accurate picture of their progressive exhaustion and, indeed, indicate their ultimate ruination. His studies revealed a 50 per cent. decline of oyster population in a period of three years (1879–1882). The announced results were dismaying. He pointed to the accidents and enemies of the oyster, especially during its first year of life. A change of climate was appealed to by some in explaining the decline of the supply; others thought that the taking of oysters for private use in the summer was the chief cause; still others threw the blame upon the officers of the Fishery Force. Measures of conservation were nobody's business.

Brooks called for an annual examination of the industry and the recognition of the essential failure of public and private management. Instead of relying upon the lazy, vague and ignorant principle of the "play of natural forces," he pleaded for the artificial increase of the oyster population, just as the domestication of sheep, cattle and poultry had displaced the hunting of wild deer, wild buffalo and wild turkey. He wrote in 1890, "We live in a highly civilized age and if we fail to grasp its spirit we shall go to the wall in the oyster industry."

It was thought doubtful if the industry could get better until it had become decidedly worse. Short of widespread social effects, how could the people of the state appreciate the situation and apply scientific remedies? Brooks called attention to the absolute silence in which a prior statement of his rational remedies had been received. He recommended laws requiring the return of shells to the beds; he calculated the loss to the state if the practice of gathering and selling immature oysters were continued; above all, he encouraged oyster planting in Chesapeake waters. The prohibition of dredging would not save the beds. Laws shortening the season would not effect any great improvement, he thought.

I shall make no attempt to present the complete case as set forth in his book first published in 1890 and republished in 1905. The point is that he made a scientific study of a biological form, ana-

lyzed an industry built upon it and forecast specific social effects. His work has stood every test of criticism for fifty years. He brought experimental science and new discoveries of the laboratory to bear directly upon a large industry in a small state. He predicted with accuracy the course of events during the next fifty years if the findings of science were ignored. The fatal evolution of the industry in the past half century is one of the most remarkable validations of scientific method which we know. He dealt out foundation material which was rejected by the political builders.

During the ensuing half century successive legislatures sought to protect and encourage the industry, but they did so by consulting so-called "practical" oystermen. Lay opinion was substituted for scientific opinion, the profits of the moment for continuing profits. Compromise of conflicting interests in the bay region were sought to provide a form of democratic control with little regard for the substance of the problem.

I have ventured to present this somewhat detailed account of a single industry in order to point a moral. Scientific methods and political methods are too often incommensurable or are made so. The democratic process requires debate, general knowledge and education, and, in the final analysis, compromise. If these form the essence of the process, they impose severe limitations. In scientific matters we may reach a point where we may say with confidence, as Brooks said, "Science tells me that the effects of the present policy will be disaster." The politician meets this statement with the observation, "Come now, you don't know everything. Let's look at the *practical* issues involved in this matter. Are you unwilling to compromise? Is not compromise the very essense of the democratic process?"

Most human situations can be compromised on a basis of fairness because a sense of fairness rests not upon statistics (of wages and cost of living, for example), but upon a *feeling* with respect to these things. But we do not study atoms or oysters by feeling! Nor does feeling count when it comes to the study of chlorophyll or pigmentation or the social conditions favorable to the spread or control of disease. What science gives in these instances is precise or closely accurate results over vital sectors of the problem. Thereafter, measures of control are validated on the basis of determined cause and effect, not on the basis of compromise as to the relation of cause and effect. Over some parts of the domain of science, we have precision, sureness, forecast; these findings sometimes point to a right way and a wrong way but not to a middle way of compromise.

While I believe in the democratic process and in the ultimate attainability of the ideal, I can see no present answer to the above dilemma except that of education. True, we shall have selfishness and deviation to deal with even if all are educated to the truth. But in just the proportion that we increase the area of reasonably sure knowledge and conclusion and high probability of correct forecast, we diminish the area which selfishness can safely or secretly occupy. We do even more than this; we *show up* selfishness or deviation. The findings of science thus reveal more than science. But science does not give us the total social answer. It does not close the gap between findings and actions. An instinct for the practical and the fair has its place. Interest will still be a major propelling force when we have had all the science that the human race can evolve. Social action is based upon assumptions (expressed or implied) respecting human values. Feeling and "judgment" will continue to play their vital part in the totality of human affairs. Ideas, beliefs, habits and the customary mental concepts that hang in the picture

galleries of our minds will still color when they no longer guide our behavior. The essential thing is that we shall recognize these forces for what they are and appraise them for what they are worth.

III

The hopes of society make half the problems of society. These hopes are mainly untested ideas and half-formed judgments that grow in pools of limited experience and knowledge. A science of society, or science applied to society must take account of human hopes, how they form, the facts of their existence and impact in the evolution of social programs.

Science has opened the door for hope on innumerable occasions. We may mention two great categories of achievement among many: a knowledge and command of the material or resource environment in which we live, and a rising knowledge and command of world resources outside our respective neighborhoods. It now faces the exigent task of appraising and *apportioning* the world environment, not alone the national environments of power-creating peoples of unequal size and opportunity. That appraisal has as its first task the effect of existing exploitation upon both human stock and "natural" resources.

New land was once the hope of the world: it was an outlet for overpopulated lands or lands of diminishing opportunity. Economics and sovereignty joined in pointing to the future wealth which new land would supply. What was not considered was the longevity of the soil from which the vegetable wealth was to be drawn. One hundred years ago the world contained but half its present population. It results that until our time new soils had not been tested sufficiently to know what they would *continue* to produce and what demands would be made upon them by the astounding increase of world population and industrial demand. No early end was seen to world migration, world productivity, world capacity: Malthus' predictions lay in the distant future. Students talked of the *exhaustion* of soil fertility, not of the *destruction* of the soil itself. A swift fate has overtaken our dreams of tropical inexhaustibility, of lands where "seed time is perpetual" and "harvests never end" as Maury expressed it in 1854. No less than the temperate or optimum lands, the tropics now have their acute problem of soil conservation.

Modern material civilization, pushing into the tropics, has piratically extracted from tropical soils and human labor in many conspicuous instances a short-term tribute for which an accounting is now required in the face of obviously destructive effects. Commanding a vast number of power units per individual, employing diversified technologies and offering tempting trading goods, our producers, merchants, and engineers have been able to get what they wanted on a vast scale and on profitable terms. Large-scale agricultural enterprise in the tropics is still new but time enough has elapsed to permit a judgment on methods both in relation to the immediate objective and to the future of the tropical lands as a whole.

It is no longer enough to say that tropical peoples ought to be grateful because beneficial health measures have been introduced or because material equipment has been increased. Whether because of the concomitantly increased pressure of population or because of the white man's insistent demands for ever-cheaper and more abundant tropical production the heritage of the land itself has been wasted. "From Cape Town to Cairo, European influence has been responsible for the rapid, and in places now uncontrollable biological deterioration of the land" is the way Jacks and Whyte sum up the soil erosion problem in Africa. From their book "Vanishing Lands" (1939) and its predecessor "Erosion and

Soil Conservation"[1] (1938) and from Lord Hailey's monumental report "An African Survey" (1938) can be drawn a wide range of instances of the failure of the white man in his role as protector of the human and other resources of the tropics.

"Money has poured into these (African) countries to release their slender reserves of soil fertility." Again, "The people have been pacified before the elements." A part of the effect is due to peace imposed upon formerly warring tribes by European rule and a corresponding population growth that has demanded that forests should be cleared, the periods and the extent of fallowing reduced greatly, and pastures overgrazed or occupied by hungry farmers seeking additional crop land; to economic arrangements which provide a higher standard of living; and to science which has annihilated insects and vermin in conspicuous instances in which they held the balance between organic and inorganic forces of nature.

This is the case in Uganda as summarized by W. S. Martin:

> Prior to British administration no crops were grown for export and cultivation was limited to the area necessary for food production. The banana-eating tribes cultivated gardens of often 3 to 5 acres in extent, but preserved them from erosion by mulching with leaves and split stems. They also cultivated small areas of subsidiary food crops, such as sweet potatoes and beans, but these were frequently grown together in the same plot and the soil was thus exposed for short periods only. Their implement was the primitive hand hoe, and the larger trees of the natural vegetation were rarely cut down. Their cultivations were scattered through the bush and the elephant grass, and under such conditions erosion was very limited. Similarly the grain-eating tribes cultivated small scattered patches; although these were situated in areas of light, easily erodible soil, they were usually so small that neither wind nor water could effect erosion.
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> With the advent of European administration tribal wars ceased. Medical and veterinary science controlled the diseases to a large extent, with the result that the human and animal population increased. Simultaneously trials of cash crops for export were made and 30 years ago it was becoming clear that cotton was the crop best suited to local conditions. At first the cotton plots were quite small and scattered in a manner similar to the food plots, but every plot of cotton represented an addition to the area cultivated. At first the native undertook the cultivation reluctantly and under official persuasion, but soon realized the advantages of money and gradually became accustomed to new standards of luxury. To achieve and retain these and to pay his taxes he gradually increased his cotton cultivations. The cotton acreage in Uganda in 1916, 1926 and 1936 was 133,000 acres, 533,000 acres and 1,500,000 acres.[2]

Particularly severe is soil erosion in the densely populated Teso district of eastern Uganda. The gently undulating surface and light short-grass bush soils lend themselves readily to the plow, which has largely superseded hoe cultivation. Where there were 300 plows in 1921, fifteen years later there were 15,388; and a toll has been paid in eroded and abandoned fields. Little wonder that indiscriminate introduction of the plow into Nigeria is viewed with alarm. Native economy is not always a destructive economy: frequently the methods evolved by the native farmer are well adapted to conditions as he finds them. Stamp describes the farming methods of Southern Nigeria as affording "almost complete protection against soil erosion and loss of fertility." Within limits the untidy, weedy patches of cultivation scattered among the bush fallow "represent the most efficient type of farming for the conditions" and "it is to be hoped that Southern Nigeria may long be spared the danger of the plow."[3]

In some parts of Kenya devastation is such that "nothing short of the expenditure of enormous and quite impossible sums of money could restore the land

[1] *Bull.* 25, Herbage Publ. Series, Imperial Bureau of Pastures and Forage Crops, Aberystwyth.

[2] Jacks and Whyte, "Erosion and Soil Conservation," p. 105, 1938.

[3] *Geog. Rev.*, 28: 32–45, 1938.

for human use above a bare and precarious subsistence standard."[4] In the Ukamba Native Reserve more than a third of the total area is badly eroded as a result of bad farming methods and overstocking: in the Machakos section where the rolling hills have been denuded of their forest capping gully erosion is widespread; in the more level Kitui section where cotton cultivation has recently been introduced "sheet erosion has already reached the visible stage on most cotton plots." A. M. Champion, visiting Kitui after an absence of 18 years, found that "some 80 per cent. of the foci of cultivation had, during that period, completely changed, leaving behind a deserted wilderness of a particular type of leafless thorn scrub, the only vegetation which the bare red subsoil, itself often case-hardened by an impervious crust and deeply networked into numerous runnels and gullies, could support."[5]

In Tanganyika the problem is less severe as yet, but erosion has to be reckoned with on many types of countryside—from Kilimanjaro in the north, where soil wash of the rich loams has reduced both quality and yield of the coffee plantations to the Lupa goldfields in the south, where former cultivated areas are now barren and uninhabited.

In the older cultivated regions of Southern Rhodesia such as northern Mashonaland overexploitation has destroyed many areas. The average soil loss in the Mazoe district is said to be a quarter of an inch a year. Land that grew good crops of maize a generation ago is now "desert country."

For nearly two decades A. J. W. Hornby has been preaching the evils of soil erosion in Nyasaland. "The damage caused by unsettlement, destruction of forest by fires and unregulated felling and inferior methods of agriculture has been both rapid and intense . . . it will not be many years before the limit of possible food production will be reached." He finds an important cause in "the past and present methods of most natives, the recent immigrants being most to blame."

South Africans of highest distinction have called the attention of government and people to the devastating effect of the white man's occupation of the subcontinent. The South African Association for the Advancement of Science has kept the subject in the forefront of its successive programs for many years. A Drought Investigation Commission reported in 1923. The forty-seven specialists pointed to the deterioration of soil and vegetable cover as the "main causes of the decreasing European population of the Cape Midlands." The farmer knows that drought will come sooner or later, yet he makes no provision for it, with the result that he overgrazes in times of short pasture.

In the report of the Drought Investigation Commission there is a comment which goes to the heart of the subject of this paper. The specialists state that they can not recommend any direct legislative action to control overstocking or veld fires because such action could not be enforced. They add: "Unfortunately, in a democratic country it is not possible for Governments to introduce measures too far in advance of the wishes of the average voter." The mournful conclusion is reached by Thomas D. Hall, writing in 1934, that if something is not done quickly to speed up erosion control and veld management, South Africa will one day be merely another interesting historical example of how democracy, carried to excess, destroyed itself: "We can not wait for our unteachables to act by way of the ballot box—for it will then be too late."

All South African farmers, says Du Toit, speaking at a symposium on con-

[4] Jacks and Whyte, "Erosion and Soil Conservation," p. 95.

[5] *Jour. Royal African Soc.*, 38: 442–464, 1939; reference on pp. 448–449.

servation, have had practical proof of the generally low quality of their soils. Very few, however, have realized that to cultivate them by methods practiced in more favored lands is to put too great a strain upon "this tender cuticle of the earth."[6]

These examples have been drawn from Africa, but we could draw equally well from other tropical and semitropical lands—the teak and rubber plantations of Ceylon, the deforested foothills of northern India from Assam to the Siwaliks, in many islands of the West Indies; even in Java, where tropical agriculture records such admirable successes, there are "dying" lands.

Both native cultivations and European plantations suffer. "Nearly all countries which have been opened up for any kind of 'planting' afford striking object lessons in what ought *not* to be done."[7] The exploiting white man has been unable to make his economic scheme take account of the science that has given him power over the native and his land.

It is asserted that in one tenth of the time that it takes to develop serious erosion upon soils of the temperate regions, tropical soils begin to show erosion effects where erosion potential is evident. But not all tropical soils suffer from erosion. Deviate but slightly from appropriate methods of land utilization, as by shortening the rest period of shifting cultivation and the soil-plant organism responds sensitively with destructive effects. Each crop and each method of cultivation must be studied in relation to each soil type, each vegetation type, each rainfall type, each slope gradient, in combinations that have to be analyzed fundamentally to provide an acceptable long-term scheme of cultivation.

Rainfall in the tropics is predominantly a matter of heavy downpours in short intervals of time, and in many parts of the tropics the total annual rainfall comes almost exclusively in the wet season. The type of cultivation suited to a given soil is therefore a matter not only of soil structure alone but also of rainfall conditions in detail. Each regional environment is a different thing to different groups of people accustomed to distinctive food crops and modes of tillage.

Vageler concludes that it is hardly too much to say that more than 75 per cent. of all failures in tropical and subtropical countries are due to the choice of unsuitable land.

The Second Conference of East African Agricultural and Soil Chemists held at Zanzibar in 1934 discussed the principle of "making surveys before framing policies." "There was need," it was argued, "for a field study of eroded and potentially erodible areas, in which not only the present intensity of damage should be reported upon . . . but also the soil profile and all the factors associated in its development."

A world-wide comparative survey is indicated. We do not know enough about the weathering processes that affect the soil-making and soil-maturing processes of nature. Organic acids, soil micro-organisms, vegetal cover and population balance are elements in the problem. A rapid ecological survey can not take the place of a thorough soil and climatic survey. Vageler quotes native opinion that in the Dutch East Indies three years are enough to destroy the richest humus, if the trees are felled and the soil exposed. The principles of good soil management in the tropics have yet to be determined. Temperate zone analogies are misleading. The principles must be more widely recognized and surveys must be made before policies can be framed.

We have assured profits for the time being to commercial enterprises in the far-flung acreages that now lie devas-

[6] *South African Jour. of Science*, 35: 20, 1938.
[7] *Empire Cotton Growing Review*, 6: 297, 1929.

tated and barren. We have equally assured the destruction of the soil. All our other scientific achievements in tropical exploitation will fall if the base is destroyed, and that base is not profits but the land upon which tropical peoples dwell. These peoples know nothing of our objectives. Nearly 100 per cent. of them must make their living by growing crops or raising cattle. Unless we build up a permanently productive soil, tropical production in the devastated lands will collapse and all our engineering skill and our control of tropical diseases will be but memorials of misused power.

The point is of crucial importance at the present time because the control of tropical diseases, both human and animal, and the introduction of air-conditioning in living quarters are likely to result in an even greater demand for and utilization of the most suitable and still uneroded tropical soils. In the absence of any clear philosophy of control by society of the forces which science has delivered into the hands of this generation, and in the face of the limitations imposed by political management, tropical exploitation bids fair to become a major problem in world recovery following the present war when both production and distribution will make fresh demands upon our wit and our science.

I fear that I have been writing for the converted merely, to those who are in no need of either example or moral. The millions of people who may be in need will not hear or read these words. But the scientific man has an obligation thrust upon him. It is to debate and to decide in the company of his fellows on a course of action with respect to the progress of science and the weighting of its social effects. Thus will be provided either some degree of confirmation or some disclosure of weakness in our conclusions or our judgment. Perhaps it may also make each one of us a more intense and effective advocate of the spirit of science in human dealing: objectivity, an even-tempered attitude, and respect for the limits as well as the contributions and the possibilities of science. The total effect which scientists produce may thus come in time to be large, or to paraphrase Aristotle: Each of us may add a little and from the whole there may arise a certain grandeur.

SEVENTY YEARS OF SUEZ

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THE year just passed marks the seventieth anniversary of two epoch-making events in the history of world transport. One of these events occurred at Ogden, Utah, at that time an obscure frontier village. There, the driving of a spike of gold and another of silver marked the completion of the first transcontinental railroad across the North American Continent. The other event was a colorful pageant staged in the Land of the Pharaohs. At Port Said, on November 17, 1869, lay the French royal yacht on whose deck was assembled a remarkable gathering of world celebrities, among them Count Ferdinand de Lesseps. At a given signal, the bands struck up, and amidst the cheers of the crowds on shore, the banner-bedecked yacht headed south, leading a parade of half a hundred ships, the first to pass directly from the Mediterranean to the Red Sea through the new Suez Canal.

In the three quarters of a century which has passed since that historic celebration, Suez has played a leading rôle in the world of commerce as well as in European politics. Its strategic location both for peace-time traffic and for military and naval operations has made its construction, operation and control matters of great international concern. As a consequence, the major problems of those in charge have from the very beginning called for the talents of a diplomat as well as those of an engineer.

As at Panama, the transportation history of the Suez Isthmus passed through the three successive stages of (1) pack animal, (2) railway carriage and (3) waterway. From remotest antiquity men and camels had plodded across this 100-mile portage of hot drifting sand, bearing the precious bales of merchandise from the Far East. Oftener still, the route crossed from the Red Sea to the Nile, thence down that river to the Mediterranean. At various times in the past this latter land link was even canalized, but for the decade preceding the completion of the Suez Canal, a railroad from Cairo to the Red Sea at Suez performed this portage service. Finally, in 1869, the isthmus was cut and ships passed directly between the Mediterranean and the Red Seas.

The trickle of traffic which started through the new waterway in November, 1869, required a few years to get really into its stride. Century-old routes with their equipment, sailing schedules and their long-established port and business connections could not be uprooted overnight. Prejudice against the new waterway, especially in Britain, died hard, and it was not until two years after the opening that the British Government consented to use it for its India mails. The advantages it offered, however, especially for the Asiatic trade, were so great that the "trickle" soon became a sizable "stream," as shown in Fig. 2. To-day, some 6,000 vessels carrying upwards of thirty million tons of merchandise pass and repass in that narrow defile. This short cut between East and West has quickened the economic life of the lands bordering the Indian Ocean as well as those of the western Pacific. Likewise, it transformed the Mediterranean from a "blind alley" to a through route and raised it to a position second only to the North Atlantic among ocean highways.

The engineering problems met with at

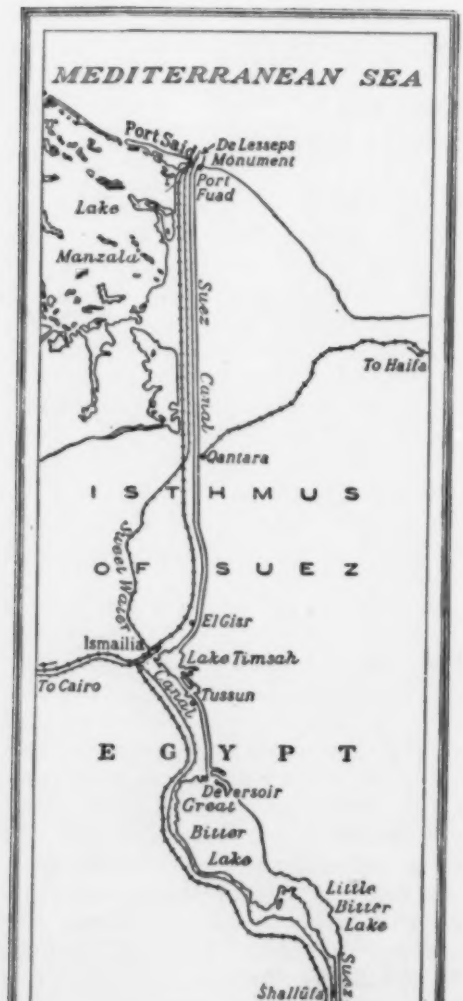

FIG. 1. SUEZ CANAL SYSTEM
SUEZ AND SWEETWATER CANALS SHOWING THE RAILWAY AND ENVIRONS.

Suez were not at all comparable with those at Panama, a fact that de Lesseps discovered later, much to his sorrow. True, both engineering and medicine had made tremendous progress in the half century which elapsed between the completion of the one project and the beginning of the other; yet the natural obstacles, geologic and climatic, encountered at Panama were, by comparison, enormous.

Panama required a huge cut to be blasted through a mountain of solid rock. At Suez it was largely a matter of dredging out mud and sand; in fact, a considerable part of the excavating was done by an army of some 25,000 laborers, who shoveled the dirt into baskets, loaded them onto donkeys who, in turn, carried and dumped it beyond the edges of the great ditch. This led, in the former case, to an expensive and complicated lock-type of canal in which ships had to be raised and then lowered some 85 feet—literally "lifted" over the continental divide. For the other, a simple sea-level waterway was quite feasible.

Climatically, also, Panama was much more seriously handicapped. Situated in the humid tropics, some of its major problems centered about the disposal of excess water and jungle growth and the elimination of diseases that were associated with such a setting. At Suez, on the other hand, one of the most difficult tasks was to secure *enough* fresh water for the workmen. In the first years of construction, water for the army of laborers had to be brought from the Nile by camels at an enormous cost—some $2,000 a day! By 1863, there was completed a diversion canal which brought fresh water from the Nile. Likewise, in the arid climate, the absence of a vegetation cover permitted the drifting of sand that constantly threatened to refill the excavation. The answer to this menace was found in a program of continual dredging, as well as in putting a low speed limit on ships using the waterway so as to reduce the wash of the banks.

The early routes that usually led from

the Red Sea across to the Nile necessitated the navigation of the delta of that river—always a difficult feat. De Lesseps' decision to construct the new canal across the Suez Isthmus served to avoid the delta problem. However, the currents in this part of the Mediterranean carry the Nile mud eastward and a long breakwater has had to be built to prevent the filling in of the mouth of the canal.

The Suez route is but one of many competing routes joining Europe with the East. These highways extend all the way from the Arctic on the north to the Cape of Good Hope on the south, and they include water, rail caravan, air, auto truck and oil-pipe lines, as well as combinations of two or more of these. Even the Panama Canal and the Straits of Magellan are competitors within certain areas. The severity of the competition offered Suez varies, of course, with the particular regions concerned, as well as with a large number of variable factors, such as charter rates, canal tolls, insurance rates, fuel prices enroute and the character of the harvests.

As illustrative of the influence of location, the case of India and Australia, trading with western Europe, will serve. As shown in Fig. 3, Suez offers a saving over the Cape route of about 4,500 miles for India, but only about 1,000 miles for Australia. For the latter, a tramp vessel going via Suez saves only three or four days of sailing—often not enough to justify the heavy tolls. As a result, much Australian and New Zealand shipping still moves around Good Hope.

Likewise, if charters are low, savings in distance are less important. During the recent depression ship earnings were so small that the time element was of minor importance and many shipping lines shifted routings to avoid the high canal tolls.

Occasional changes in the canal tolls and the insurance rates over certain routes are sometimes important factors. Recently when the Italian-Ethiopian conflict and the Spanish civil strife brought war-clouds to the Mediterranean, the increase in war-risk insurance rates there diverted much shipping via the Cape. Even oil tankers from the Persian Gulf and some passenger vessels took the longer but cheaper route.

The availability of cheap fuel en route is often a strong factor in the choice of routes. The development after the World War of the Natal coal deposits in South Africa, providing cheap bunker coal at Durban, and the more recent large output of oil from Iraq and Iran exert an enormous influence upon the popularity of routes passing nearby.

Other competition is offered by routes across Arabia or Asia Minor. Auto-truck lines join the railhead at Damascus with Bagdad, and 1939 saw the completion of the old Berlin to Bagdad line. Air routes from western Europe to the Middle East and Far East cut into the mail, express and passenger movement which

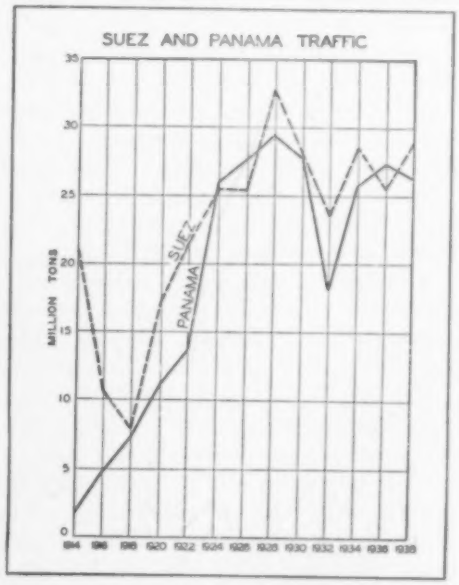

FIG. 2. TRENDS IN CARGO TONNAGE AT SUEZ AND PANAMA. COMPUTED BY CALENDAR YEARS.

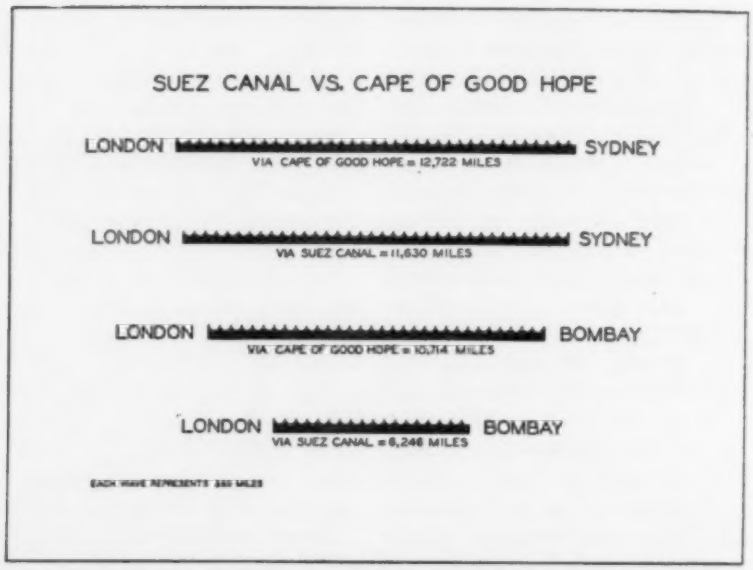

FIG. 3. MILEAGE SAVING OFFERED BY SUEZ OVER CAPE ROUTE

otherwise might go via Suez. A unique and interesting development is the recently completed oil-pipe lines from Iraq to Haifa and Tripoli. Operating at full capacity, this system is able to shunt yearly one third of a million tons of crude petroleum overland direct to tidewater on the Mediterranean.

All in all, it is the route via the Cape of Good Hope which is the most formidable competitor of Suez. The canal never did succeed in attracting *all* the traffic from that route, and it requires but slight changes in economic conditions to increase the proportion going around Africa.

The great bulk of Suez shipping moves between western Europe on the one hand and the borders of the Indian and Pacific Oceans on the other. The one is a highly industrial region, and the other, an area in the raw material-foodstuff stage of development. As a consequence, the Suez route, like Panama, suffers a lack of balance, the northward-moving cargo tonnage being about twice that southbound. Bulky coal from Europe and high-priced tea from Ceylon and India are exceptions to the general rule. Without them the disparity in movement would be even greater.

An analysis of the canal traffic shows that commodities moving south comprise a multitude of manufactured or semi-manufactured articles, while on the return trip there are great staple foodstuffs or raw materials, few in number, but large in quantity. As shown in Fig. 4, of the southbound traffic, metals and machinery occupy first place; in fact, it is the only group in Class 1, *i.e.*, making up as much as a million tons per year, for the period shown. Fertilizers, cement, railway material and coal follow in the order named. Northbound there are a number of groups in the "million-ton class." Mineral oils, vegetable oils (soybean, copra, linseed), cereals (wheat, rice), textile material (jute, cotton) and minerals (manganese, tin) are five such groups which together account for about one half of the whole movement.

Passenger traffic through Suez is of more than ordinary interest since passengers pay a toll charge. Normally, the number averages a little less than

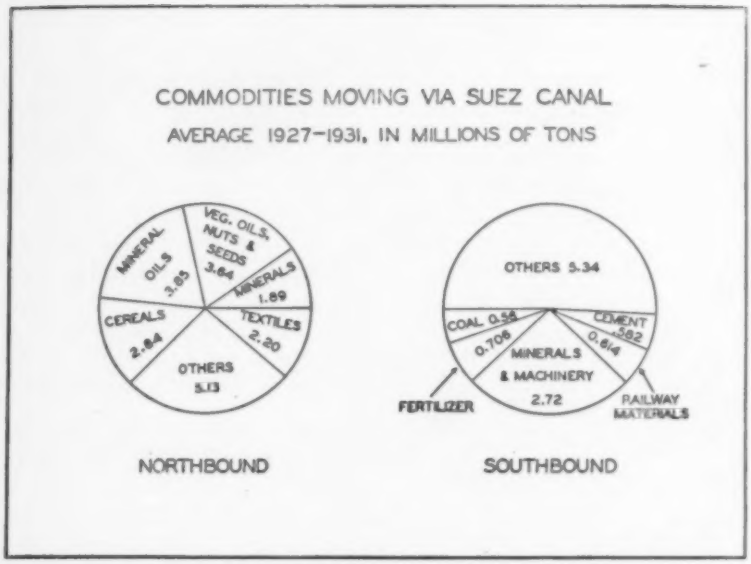

FIG. 4. AN ANALYSIS OF CANAL TRAFFIC

300,000 per year, but in 1936 the Ethiopean conflict sent an extra half-million soldiers and workmen through at $2.00 each. The revenue from passenger movement normally yields about $750,000 annually.

Of the regions most affected during a normal year, *e.g.*, 1934, the relative importance of those east of Suez is shown in Fig. 5. India and the Far East are seen to be about equal and together account for about one half of the total. The Persian Gulf, Australia and the Singapore regions follow in that order. Since 1934 conditions have been very abnormal. The Italian-Ethiopian struggle stimulated the movement of both cargo and passengers to the Red Sea ports, while the oil boom increased the importance of the Persian Gulf.

The phenomenal growth of the canal's business, the vital character of many of its services and the varied and widely scattered interests which are concerned with its use have inevitably led to a multitude of problems—strategic and political—as well as economic.

The canal is owned and operated by a private stock company with a franchise from the Egyptian Government — an agreement having some thirty years still to run. The shareholders are almost entirely French investors and the British Government. Because the rules of the company limit the maximum number of votes of any stockholder to ten, irrespective of the number of shares he possesses, the actual administration of the company's affairs is in the hands of the French, who have nineteen of the thirty-two directors. The responsibility for the defense of the canal has been gradually taken over by the British. The enormous revenue is derived from tolls which are paid, of course, by the whole shipping world.

The canal was built against the advice of the best English engineers and in spite of the vigorous opposition of English statesmen. Yet, when once completed and in actual operation, England recognized its value as a short-cut to her eastern empire and seized the first opportunity to purchase a large block of the stock. Her political and military policies in Palestine, in Trans-Jordan, at

Aden and in Egypt have been actuated by her desire to safeguard her communications through the canal.

England's assumption of the position of military guardian of the canal has given rise to fears by other nations that she might, on occasion, use it as a powerful military weapon. During the Italio-Ethiopian struggle, for example, there was a wide-spread demand made for her to close the canal to Italian shipping. Even the suggestion of such action was sufficient to prompt Mussolini to demand a share in the canal's control—a demand made with more fervor inasmuch as his treasury had just paid many millions in tolls in connection with Italy's African campaign.

It would seem, however, that in a major European war the strategic importance of Suez has declined—at least for merchant shipping. Modern aircraft and submarines have made the Mediterranean so hazardous that during such a war most merchant vessels have been diverted via Good Hope. During the World War about one half of the losses of British shipping occurred in the Mediterranean and that was when both France and Italy were allies and all the rest neutral, except Austria, Bulgaria and Turkey. During the present struggle, the Mediterranean is reported to be practically closed, British ships being advised to use the Cape route.

The chief criticism of the Canal Company, however, is against the exorbitant tolls. Sir Arnold Wilson[1] estimates that the Suez charges amount to an average levy of about 3 per cent. on the value of cargo. For cheap merchandise, *e.g.*, East African sisal, it may be as much as 30 per cent. As a consequence, English goods in the Indian Ocean have been seriously handicapped in competition with those of Japan.

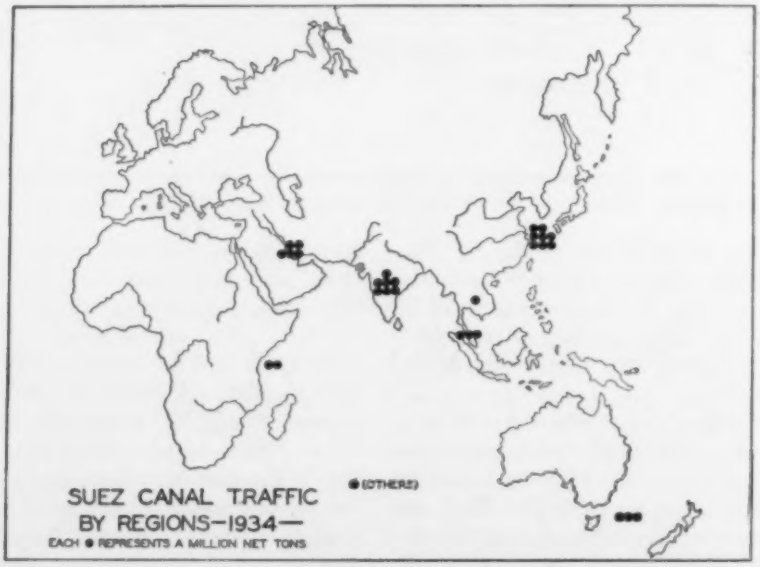

FIG. 5. RELATIVE IMPORTANCE OF REGIONS AFFECTED BY SUEZ

Shippers naturally cite the case of the Panama Canal to support their charges. The latter cost about two and a half times as much as the Suez waterway, and the maintenance expense of the two is in about the same ratio. However, Suez

[1] Sir Arnold Wilson, "The Suez Canal, Its Past, Present and Future," 1933.

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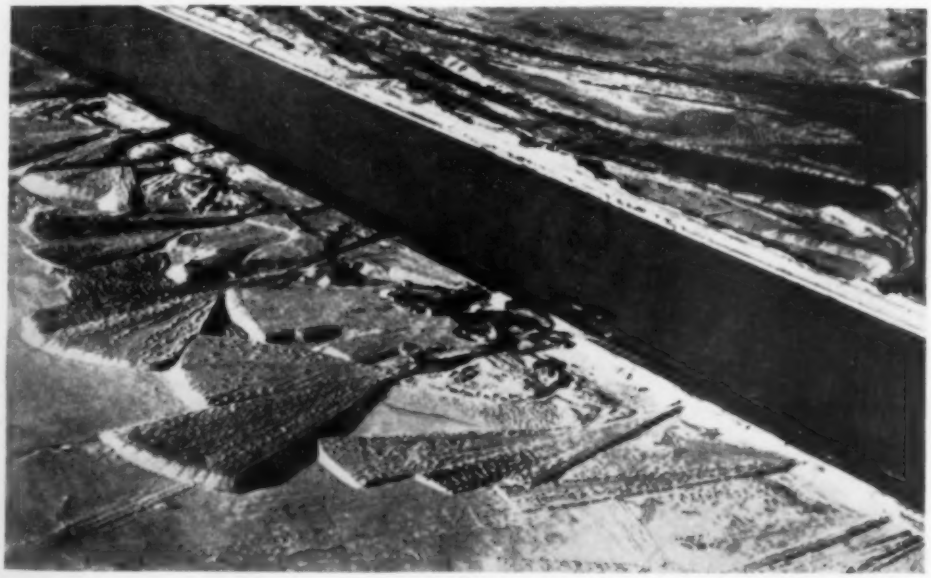
FIG. 6. CONTINUAL DREDGING TAKES PLACE

THE CANAL DEPTH IS SUFFICIENT FOR ALL SHIPS EXCEPT A FEW OF THE VERY LARGE PASSENGER LINERS. THESE KEEP THE DREDGES WORKING OVERTIME.



Courtesy British Air Force

FIG. 7. FAN-LIKE DEPOSITS OF THE DREDGES

DRIFTING SAND IS PREVENTED FROM REFILLING THE CANAL EXCAVATION. CANAL STATION IS SEEN HERE IN THE CENTER.

rules for ship measurement result in much higher figures than do those of Panama, and, in addition, their regulations regarding ballast are such that while tankers may frequently go in ballast, with reduced tolls, only a few freighters can so qualify, and passenger ships and troop ships almost never. Finally, Suez tolls must be paid in gold —a provision which bears heavily upon countries which have gone off the gold standard. As a result, Suez tolls are from 20 to 30 per cent. higher per net ton, or 40 per cent. higher per ton of cargo, than those of Panama.

The Canal Company, feeling secure in its monopoly privileges, has for the most part chosen to ignore the demands of the shippers. It has improved and modernized the facilities, yet reductions in tolls have been small. "Dividends—bigger and bigger"—may well be its slogan, and charges have been maintained "as high as the traffic can bear." As a consequence, the stockholders have grown rich, while complaints from shippers have been loud and long. Dividends for the past three years have been over 50 per cent. and for the past half-century have never been less than 25 per cent. By 1932, total dividend payments had repaid the original investment over 45 times. Since the World War, it is estimated that one sixth of the receipts would have provided fair dividends and a liberal sinking fund. Directors of the company hold office for life, draw about $17,000 a year and do little in return.

It has been well said that "much is rotten at Suez and the waters of the canal are muddy in more than a physical sense." A thorough overhauling of the management of the waterway is long over-due, an intolerable situation has been developing and growing resentment bids fair to force a change. Suez has become more than a mere waterway. It is an international public utility, and as such the suggestion that it should be taken over and operated by a committee of European nations would seem to have merit.

MANAGEMENT OF AQUATIC WILDLIFE IN THE GREAT BASIN

By Dr. ANGUS M. WOODBURY
DEPARTMENT OF ZOOLOGY, UNIVERSITY OF UTAH

MANAGEMENT of aquatic wildlife under climatic conditions of the Great Basin is largely a problem of management of water—the chief environment, even though the basic problem may be one of land use. Such a problem is particularly complex in the Great Basin, lying as it does between the Sierra Nevada Range of California and the Wasatch and Uintah Ranges of Utah, the former extracting much of the moisture from the Pacific winds, thereby leaving a semi-arid interior with scanty rainfall—5 to 20 inches. The Wasatch Range, rising 5,000 to 8,000 feet above this interior basal plain draws many times as much moisture from the passing winds—20 to 60 inches. The 500-mile floor of the basin at 4,000 to 6,000 feet altitude is broken by numerous smaller parallel north-south ranges rising from 1,000 to 5,000 feet above the floor.

These lesser ranges draw precipitation approximately proportional to their altitude, increasing about one inch for each 160 to 200 feet rise. Such mountains produce minor streams of water which mostly disappear in the desert. The main run-off streams come from the Sierra, Uintah and the Wasatch Mountains, collecting in two separate basins, which formed in Pleistocene times two huge lakes—Bonneville of Utah and Lahontan of western Nevada.

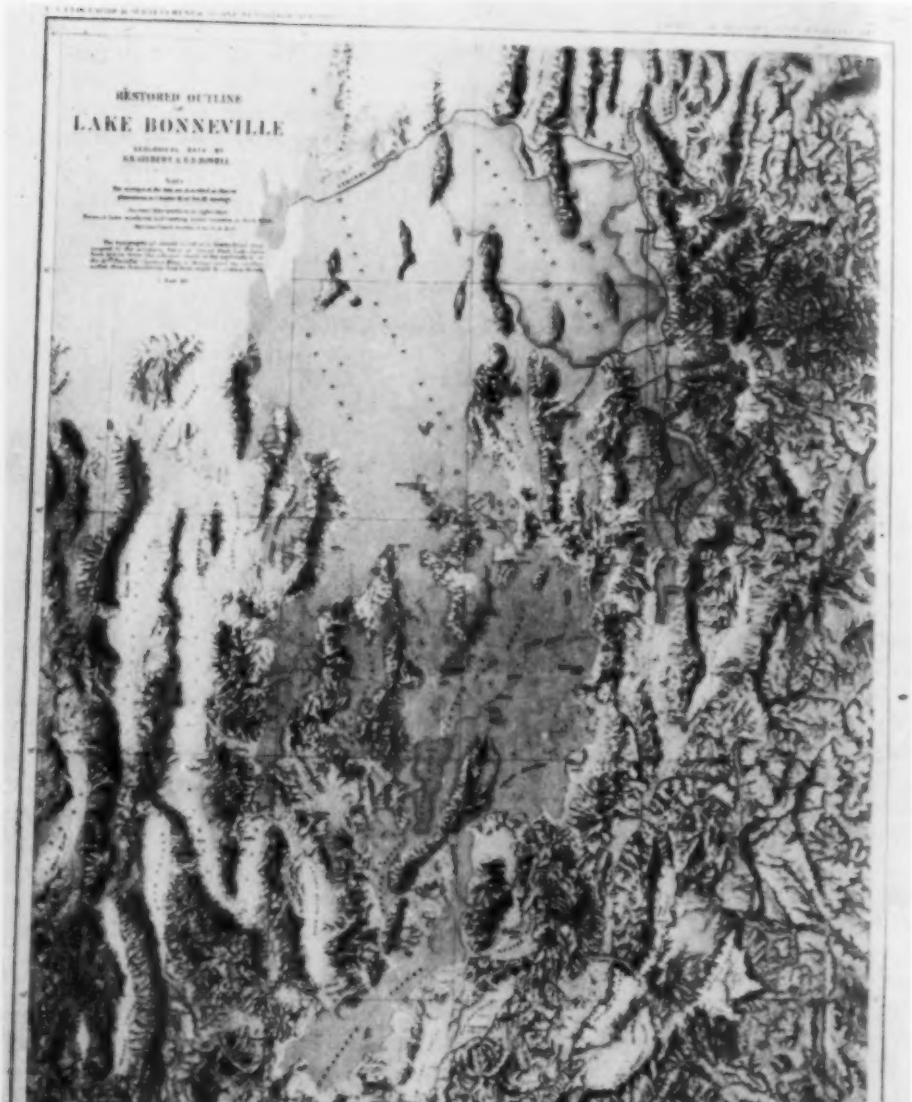
Lake Bonneville, formerly 300 miles long and 1,000 feet deep, drained out through Red Rock Pass of southern Idaho into the Columbia River drainage via the Snake River.

Degrading its bed through the pass, it left two principal shorelines, the Bonneville Terrace at the top and the Provo Terrace about 375 feet lower, where the degrading was halted by a hard rock stratum in the pass. With lessened moisture supply, this lake was further reduced by evaporation, leaving the Great Salt Lake as its principal remnant and several other remnants of lesser size.

Similarly, Winnemucca and Pyramid lakes in Nevada are the principal remnants of Lake Lahontan, but in contrast with Great Salt Lake these lakes have been fresh enough to support one of the world's largest trout, *Salmo henshawi*, although in recent times diversion of inflowing water has so reduced the size of the lakes and so concentrated the salt in them as to eliminate trout from Winnemucca Lake and threaten extinction of this unique species from Pyramid Lake. The salt accumulations in these lakes, however, will probably never equal that of Great Salt Lake, since the inflowing waters drain non-marine and igneous rock formations, whereas those of Great Salt Lake drain marine sediments with heavy salt concentrations.

The problem of water management begins with falling raindrops and snowflakes and increases in complexity with each successive step of water movement. Snow falling in the winter accumulates in greater quantities and for longer periods at successively higher altitudes, acting as storage reservoirs that release their pent-up waters with the increasing temperatures of spring and early summer. In a few cases, perpetual snow banks or incipient glaciers remain throughout the summer.

The water from melting snows or rains may be absorbed in the ground up to the



GILBERT'S MAP OF OLD LAKE BONNEVILLE

SHOWING ITS FORMER OUTLINE AND DRAINAGE AND ITS PRESENT REMNANTS IN SEVIER AND GREAT SALT LAKES. PHOTO BY UNIVERSITY OF UTAH.

holding capacity of the soil, beyond which it will run off or evaporate. Absorbing capacity of the soil depends upon several factors such as rate, slope, texture and aspect, but chiefly, according to Forest Service investigations, upon the presence of living or dead organic matter either in or on the soil. The greater the organic material, the more water is held before run-off occurs.

The percolating soil waters serve as second-line reservoirs from which the retarded waters tend to emerge farther down the mountain slopes as springs and form the sources of permanent streams and lakes that are more or less constant. Thus the surplus water from intermittent rains and snows of the higher mountains are by means of snow and soil storage transformed into perennial streams that flow into the lower altitudes, where rainfall does not equal evaporation. They flow into the basin depressions where, barring human interference, they accumulate until evaporation offsets the inflow.

Every step in the downward progress of the water from mountain peak to basin bottom is affected by variations in temperature, light, soil, soluble minerals, topography, aspect and other factors of the environment. The accumulated differences produce striking contrasts in habitats to which the wildlife must adjust.

In the glaciated mountain tops, snow-fed cold-water lakes, with little dissolved mineral matter and high oxygen content, provide a meager food base of algae, worms, mollusks, crustaceans and insects, culminating in crops of trout which serve as sources of fishing for ospreys and mankind.

The swift, well-aerated mountain streams descending the steep slopes tend to increase the mineral content and temperature as they descend toward the valleys. The aquatic life which would persist must be prepared to resist the driving force of the current by swimming or clinging or else avoid the current by other means. Trout, water ouzels, king-

SAMPLING STREAM BED FOR FISH FOOD ORGANISMS[1]
IN THE GREAT SALT LAKE BASIN. U. S. BUREAU OF FISHERIES.

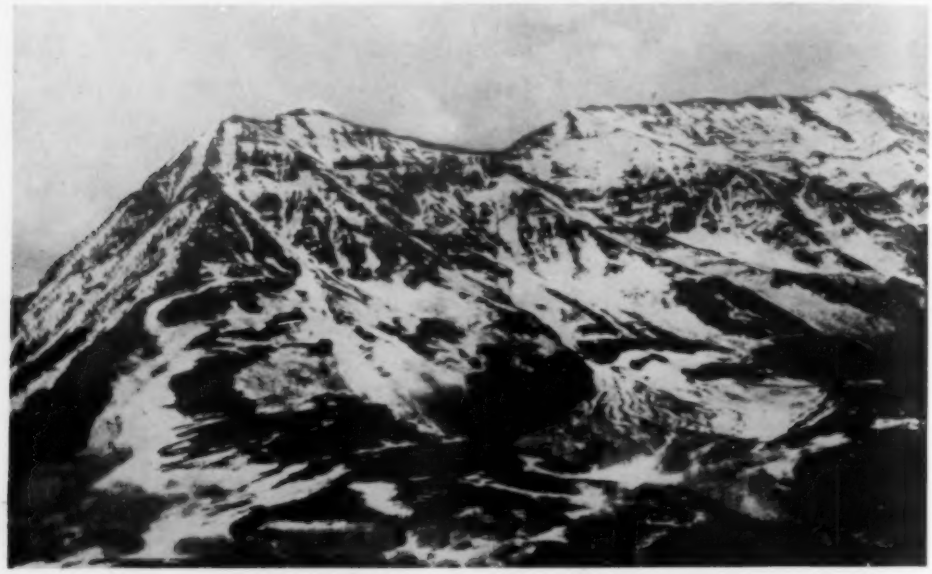
[1] Photographs not credited are reproduced by the courtesy of the U. S. Forest Service.

fishers, mink and beaver are the chief vertebrates involved.

As the streams reach the valleys the gradient is gradually reduced, thus slowing the streams, the rocky bed gives way to gravel and sand, the mineral content increases and the waters get warmer. Coalescing with others, they tend to form slow or sluggish warm-water streams before they empty into the basin depressions. The species of algae and invertebrates change and the trout are replaced by warmer-water fishes.

The Great Salt Lake, with its saline content approaching saturation, presents a hostile environment to most living organisms, although a few algae, a brine shrimp (*Artemia gracilis*) and two brine flies (*Ephydra gracilis* and *E. hians*) are able to meet the physiological exactions imposed in order to extract moisture from the salt solution, and some island-nesting birds find suitable rookery sites on the secluded islands of the lake.

In the Great Salt Lake drainage basin, the higher mountains (8,000 to 11,000 feet) bear spruce-fir forests, except where higher mountain peaks rear their snow-clad summits above timber line. These forests aid the storage of snow by holding and shading, thus delaying the melting period. They also provide litter and humus for the soil, which increase the absorbing capacity of the soil and add to the underground water supply for springs.



MOUNTAIN PEAKS STORE SNOW

WHICH REMAINS MUCH LONGER THAN THAT WHICH FALLS ON LOWER SLOPES AND VALLEYS.

The valley lakes and ponds vary from fresh, well-oxygenated water suitable for trout through various stages of stagnancy and brackishness to the saturated solution of salt sometimes found in Great Salt Lake. The intermediate stages provide suitable habitats for muskrats, for plant and invertebrate foods of waterfowl and for the so-called "trash fish" (carp, chubs and suckers) that furnish a prolific source of food for the fish-eating birds (pelicans, cormorants and herons).

The lower mountain slopes (6,000 to 8,000 feet) are robed with deciduous chaparral—mostly oak brush—a prolific

TERRACING OF CANYON HEADS

THIS HAS PROVED EFFECTIVE IN PREVENTING RUN-OFF AND STOPPING EROSION.

source of forage for summer live-stock grazing. The foothill slopes (5,000 to 7,000 feet) generally bear pigmy forests of juniper and piñon pine, widely spaced with root systems several times as large as crowns. The open, well-drained valleys (5,000 to 6,000 feet) usually bear stands of deep-rooted sagebrush, except where replaced by human agriculture. In the lower salty soils (4,200 to 5,000 feet), shadscale, *Kochia* and greasewood replace the sage except in the extreme salt desert, where it is barren.

Each step in the descent of the water

PLANTING FISH FRY IN STREAM NEAR CACHE NATIONAL FOREST, UTAH.

Courtesy of J. E. Brandley

BIRDS OVER GREAT SALT LAKE, PHOTOGRAPHED FROM THE STERN OF A BOAT.

from mountain peak to Great Salt Lake is beset with human use, interference or management. The spruce-fir forests are cut for timber. All the plant formations are grazed by domestic live stock. Practically all mountain lakes and mountain streams and many of the valley lakes and streams are fished for sport and recreation. Water is diverted from streams for irrigation, water power, manufacturing, culinary use, mining and other purposes. Storage reservoirs are constructed and lakes are impounded in efforts to regulate stream flow. Dykes are made and lands flooded to make ponds for water-fowl and fur-bearers. Other ponds and swamps are drained for mosquito control. Some lakes are lowered by pumping for irrigation or power.

Most of these diverse interests change or manipulate the natural flow of the streams in one way or another. Most of the larger streams have similar flow characteristics, *i.e.*, the hydrographs have similar curve patterns. The basic flow derived from springs is fairly constant from July to April, but the melting snows of spring add to the basic flow and produce a marked rise of about 40 to 150 per cent. from April to July, with a peak during May or June. In addition, sudden floods of irregular dimensions at uncertain times during the cloudburst period from July to mid-September produce sharp peaks in the hydrograph.

DISTRIBUTION OF RAINBOW TROUT

TANKS WITH CONSTANT AERATION EQUIPMENT MOUNTED ON A TRUCK FURNISH AN EFFICIENT METHOD OF TRANSPORTING FISH TO LAKES AND STREAMS.

It seems generally agreed among those interested in wildlife management that maintenance of constant water level in stream or lake is a desirable goal and that deviations therefrom are detrimental to wildlife. This has a biological basis because of the consequent crowding into smaller space and resultant reduction in oxygen content and because the

BIRDS OVER GREAT SALT LAKE, PHOTOGRAPHED FROM THE STERN OF A BOAT. *Courtesy of J. E. Brandley*

RESULTS OF THE FLUCTUATIONS OF A RESERVOIR
AN UGLY BARE AREA IS LEFT AND THE AQUATIC WILD LIFE IS CONCENTRATED IN THE WATER REMNANT AT THE BOTTOM, WHEN THE RESERVOIR IS LOW.

living organisms of the fluctuating zone are subjected to such diverse aquatic and terrestrial conditions that few organisms can survive. River flood plains, storage reservoirs and the impounded portions of lakes are generally barren because of the fluctuations. Obviously, then, anything which tends to reduce the fluctuating zone will tend toward increased stabilization of wildlife.

Any plans looking toward stabilization of water level must take into consideration the diverse interests in control of the water. Custom and law give irrigation and culinary use preferential right to water. Canal diversions reduce the stream or dry it entirely below the point of diversion, although a part of the diverted water eventually finds its way back into the lower stream channels via underground seepage. In addition to the loss of fish habitats from the diverted stream bed, the danger of fish loss by stranding in the irrigated fields presents a problem of fish screens at the diversion dams.

Storage reservoirs for irrigation aggravate the fluctuation problems. Normally, storage exceeds withdrawal from the reservoir from October to April, but withdrawal exceeds storage from May to September, thus producing an annual cycle—empty in the fall and full in the spring. Even though such reservoirs catch the high water of spring and the floods of summer and thus help to regulate lower stream flow, yet the withdrawal of irrigation water during the summer and not in the winter merely shifts the stream fluctuations below the reservoir, but does not essentially alter the difficulties.

Water-power diversions reduce or dry streams for short distances, but the water is returned to the stream channel after serving its purpose. Such diversions do not otherwise affect the stream flow unless storage is undertaken, in which case the reservoir fluctuates, but the stored water is used to smooth out the fluctuations in the streams.

Mine and mill diversions may result

Courtesy of U. S. Biological Survey

ANTELOPE TAKING A DRINK IN THE CHARLES SHELDON REFUGE, NEVADA.

in bringing silt or chemical washings into the stream with the returning water, but in many cases artificial settling ponds are interposed before the water returns. Such silt, if it enters the stream, because of its covering and scouring action tends to eliminate fish foods and otherwise make the stream unsuitable for fish.

One of the most critical factors affecting stream-flow fluctuations is the serious depletion of vegetative cover on the stream watersheds, due principally to overgrazing but also to lesser causes of fire, snowslides and over-cutting of timber, discussion of which does not properly belong here. Depletion of the vegetative cover, however, reducing the absorbing capacity of the soil, makes bigger floods and higher water in the spring and consequently lessens the storage of water in the soil for the permanent streams, *i.e.*, it tends to greatly accentuate the fluctuations. The resulting erosion is disastrous not only to aquatic wildlife but also to crops, live stock, canals and reservoirs.

Those interested in wildlife management have but little control over such practices. Their problem is to make the best of a bad situation, and they are faced with several serious questions. First is the fish problem. The great demand for fishing privileges invites management for the maximum production of fish in suitable waters. The state and the Federal Government under cooperative agreement have both undertaken artificial fish culture as a partial answer to the problem. Fish-cultural practices are beset with further problems: suitable waters as to temperature, gases and mineral content; diseases, diet, life history, care and time of planting, each one of which presents a study of its own. But after the fish are reared, the question of stream stocking presents itself: where, when, how many and what size to plant. In actual administration, these questions have had to be decided by guess or political pressure. A few years ago, the U. S. Bureau of Fisheries and the U. S. Forest Service initiated extensive stream surveys to study the biological potentialities

GREAT CONCENTRATION OF FISH
AFTER UNLOADING IN SMALL STREAM. ALL THESE COULD NOT POSSIBLY SURVIVE, INDICATING THE PROBLEM INVOLVED IN STREAM-STOCKING PLANS.

PELICANS ON BIRD ISLAND
GREAT SALT LAKE, UTAH.

of the streams and lakes as a basis for management plans and further studies.

Out of these surveys came recommendations for stream improvements and stream stocking, the former designed to provide pools, shelter, shade, spawning areas and better food supply. Some forty miles of experimental stream improvements were undertaken in Utah in 1934–35. Later checking on the results has indicated that even though properly located dams and deflectors were valuable in producing more pools and ponds with greater surfaces and better food, yet floods have played havoc in certain places, filling pools, undermining banks and removing protective structures, especially in the mountain streams. This indicates the need for flood and erosion control farther upstream before such improvements can be fully successful.

The U. S. Forest Service studies have indicated that the most effective flood and erosion control is dense vegetation. On denuded lands seriously eroding areas may be checked by the contour trench system, beginning at the watershed divide and working down, in conjunction with rehabilitation of the plant cover. However, it is not economically feasible to handle an entire watershed by this method alone, but it should be supplemented by proper control of grazing of live stock and big game.

In some administrative study experiments on four barren mountain lakes, the Forest Service attempted to increase the plant foods for fish by adding limestone and phosphate rock to the water. Although some temporary increase was noted the first season, due no doubt to the increased mineral content of the water, the effect seems to have been reduced thereafter, probably as a result of the great quantity of water passing through the lakes.

Efforts have been made to induce the power and irrigation companies so to regulate their reservoirs and lakes that

there will be a minimum line below which no water will be withdrawn, the reserve to serve as a nucleus from which both food and fish can expand as the water again increases. Despite good intentions, the economic pressure during drouth years is so great that the necessary reserves are not always maintained. As a result there is a growing tendency in planning new reservoirs so to design the outlets as to provide an automatic reserve for wildlife and recreation purposes.

The second great problem is that of waterfowl. The enormous reduction in American waterfowl has concentrated attention upon management, in the hope of preventing further decreases. Because of the huge concentration of waterfowl in the valley waters of the Great Salt Lake Basin, it is of critical importance in national and international management plans to provide feeding, resting and breeding areas. It has been demonstrated that the natural areas can be greatly improved and enlarged by artificial distribution and impounding of the water. Private clubs, the Federal Government and the state of Utah have all taken part in developing new flooded areas for this purpose. Around the shores of Great Salt Lake, the strategy has been to impound the waste waters by levees or dykes and make it do extra duty before entering the briny water of the lake.

The federal project under control of the U. S. Biological Survey at the mouth of Bear River floods nearly 30,000 acres in five units above the dykes and nearly 20,000 acres below the dykes by spreading out the overflow surplus water. Here again, the fluctuation problem presents itself. During late summer, there is not always enough water to offset evaporation from the five units; hence in late spring, they are filled to capacity and the summer water is used to keep them as nearly constant as possible. In extreme drouth years, unit number four

BEAVERS AID IN WATER MANAGEMENT
PROVE TO BE EFFECTIVE AGENTS IN HOLDING BACK RUNNING WATER IN NUMEROUS SMALL RESERVOIRS AND HELP TO STABILIZE THE WATER FLOW.

Courtesy of Dr. J. E. Broaddus

SEA GULLS, GREAT SALT LAKE SHORE.

Courtesy of Utah Fish and Game Department

UINTAH MOUNTAINS—ONE OF OUR LARGEST PRIMITIVE AREAS

ONLY TRAILS LEAD ONE TO INNERMOST PARTS. CONIFEROUS FORESTS AT HIGH ALTITUDES AND THE ALPINE TUNDRA ABOVE TIMBER LINE, STORE MUCH WINTER SNOW AND THE RESULTING WATER IS RELEASED IN THE SPRING WHEN THE LOW VALLEYS ARE SWELTERING IN HEAT.

has been sacrificed and allowed to go dry in order to provide sufficient water for the others. Now proposals are being made to provide reservoir storage farther upstream to take care of the water deficiency.

How much and in what way the drying of unit four and of lands below the dyke affects the food supply is an interesting problem that needs further study. It has been noted that great concentrations of birds occur on these areas when they are again flooded and that the pondweed (Potamogeton) is not killed but recuperates readily when again supplied with water. There is little doubt that the supply of waterfowl foods has been increased enormously on the project as a whole, but further studies of food habits are now being undertaken to provide a basis for management plans.

The duck sickness is still a baffling problem, despite the claim of specialists that lead poisoning from eating shot can be distinguished from the real duck sickness by botulinus poisoning. With the discovery that one or two shot pellets picked up by waterfowl will produce severe sickness or death has come a realization that every shell fired by hunters in a marsh is a potential menace to the life and health of many birds for years to come. The shell manufacturers have the problem of finding harmless substitutes.

STREAM IMPROVEMENT WORK

MUCH OF THE WORK WAS RUINED BY FLOODS, INDICATING FURTHER NECESSITY FOR EROSION CONTROL ON THE WATERSHEDS.

Despite the old theory that fresh-water flooding of the alkaline flats would eliminate the duck sickness, occasional outbreaks still occur. Investigations have recently been undertaken to establish the origin and distribution of the causes of such outbreaks. The problem is complicated by the fact that the birds may pick up the poison at one place and become affected by it at some distant place, such as the dykes at the refuge. Further in-

Courtesy of Utah Fish and Game Department

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Courtesy of W. H. Schaffer

A TYPICAL BEAVER DAM LOCATED AT GRANITE CREEK.

vestigations by the Biological Survey in the region include studies of nesting and feeding concentrations, bird movements and airplane census estimates, the latter about 25 times per year.

Some years ago, in response to competition of private duck clubs, the state of Utah developed public shooting grounds a few miles north of the Bear River Refuge. More recently, in response to the waterfowl shortage, attention has been directed to developing reflooding projects with the avowed intention of reserving at least half of the area for sanctuaries, the other half to be open to hunting. These projects include the following in various stages of development: Locomotive Springs, Farmington Bay, Clear Lake and the mouth of Weber River. Still more recently, an experimental mallard breeding ground has been developed in the Bullock Slough near Provo, Utah, in an effort to increase the breeding of this duck under protection.

The third great problem is that of aquatic fur-bearers—beavers and mink on the higher streams and muskrats in the valley waters, neither one of which has been able to maintain adequate numbers under public control largely because of opposition by irrigation interests and because of poaching. Certain private fur farms have been able to make muskrats profitable. By comparison with early-day trapping operations and the streams suitable for beaver propagation, it is estimated that the beaver population of today is less than 10 per cent. of its potentialities. Here, then, is another challenge to management. The U. S. Forest Service and the state of Utah are cooperating in an effort to develop a large population by trapping and redistributing the beaver under the protection of private

TYPICAL EXAMPLE OF EXPERIMENTAL WORK
TO PROVIDE POOLS, FALLS AND HOLES.

individuals with special trapping permits. The question has arisen if it is not a shortsighted policy on the part of the irrigationist to object to beaver ponds on the headwaters of the irrigation streams. Will not the ponds help to store more underground water that will in the long run tend to produce more summer water?

A fourth problem is that of mosquito control in its relation to management of wildlife. The initiative was taken in Salt Lake City, where the nearby mosquito breeding swamps have been drained, thereby eliminating the aquatic habitats for fish and waterfowl. The policy seems to be, however, to save the duck clubs a little farther away and so regulate them as to prevent or reduce the water fluctuations. Special studies have been made of sources of various species, special oils suitable for a desert region and the use of native minnows and Gambusia as aids in control. It is a paradox on management, however, to see areas side by side, one being flooded for wildlife, the other being drained for mosquito control.

A fifth problem is the protection of fish-eating birds, some of which nest in rookeries on the islands of Great Salt Lake. They have in the past been severely persecuted because of their fish-eating propensities, but it is becoming more and more apparent that they feed largely upon the "trash fish," some of which compete with ducks for plant foods. The help of these birds in controlling the fish numbers in the reflooded waterfowl refuges is becoming recognized in some quarters.

A further aspect of this problem has appeared during the recent drouth. The water of Great Salt Lake had become so reduced by evaporation that it reached saturation in 1934. The precipitation of salt during the summers of 1934–5–6 was

Courtesy of Leon Stanley

SALT DEPOSITS ON BOAT IN GREAT SALT LAKE

PROBABLY DUE TO THE SMALLER SIZE OF THE LAKE IN THE DROUTH CYCLE AND THE CONSEQUENT CONCENTRATION OF SALT.

concurrent with the near-disappearance of the brine flies from the lake, whereas the brine shrimp persisted, although they may have been reduced in numbers. Apparently the brine flies returned in 1937. It has been suggested by observers on the lake that probably the salt crystals buried the fly eggs or pupae of summer, but failed to affect the shrimp eggs of winter. Weak, dying and dead pelicans have been observed with salt crystals on their feathers, suggesting that they had been trapped and doomed by the crystallizing salt which prevented them from flying. It is reported that a party of boatmen captured some of these pelicans, soaked off the crystals in fresh water, fed them and found they were so recuperated they could fly away.

A sixth problem is the question of pollution falling into three principal categories: organic decomposition reducing the oxygen content, chemical poisons from mills and factories, and mechanical irritants such as sawdust and silt. Outbreaks of dying fish have been traced to beet-pulp wastes from sugar factories and a case of pea-silage pollution has been reported. Such pollutions are, of course, more or less unusual and accidental. The potential menace to fish from sawdust by mechanical clogging of the gills or changing the pH of the water by resin is mostly avoided temporarily by storing fresh sawdust at the sawmills, but the danger of being washed into the stream by high water or floods persists for a long time thereafter.

A peculiar problem, closely related to chemical poisoning, has been represented by certain recent attempts at controlling snails that act as alternate host for livestock liver fluke parasites by means of copper sulfate. An experiment of the Bureau of Fisheries indicated that if the copper sulfate was applied in sufficient concentration to kill snails, it also killed algae, worms and trout.

In face of all these wildlife problems, there is still a more basic question for the general public to answer: What shall be done about our natural resources to stop abuses and exploitations and place them on a sustained yield basis?

DEVELOPMENT AND MANUFACTURE OF OPTICAL GLASS IN AMERICA

By M. HERBERT EISENHART AND EVERETT W. MELSON

BAUSCH AND LOMB OPTICAL COMPANY

ALTHOUGH the production of optical glass in the United States is often attributed to the World War, in which it was one of the vital materials, it would be more appropriate to say that the war merely created a forced draft under furnaces even then bright with the flames of experiment, for its production in the United States was inevitable. The importation of ophthalmic crown glass from abroad had reached such proportions that the leaders in the optical industry could no longer ignore the desirability of home production.

War, however, makes immediate and extreme demands. In the case of optical glass, a mere comparison between the Civil War and the World War will serve to explain the demand. In the conflict between the North and the South, artillery was fired at point-blank ranges. The enemy was visible, and distance was estimated with the naked eye, but the power and precision of modern guns have been so improved that relatively small targets may be attacked at ranges beyond 25,000 yards. Most of the firing is directed at objects either below the horizon or obscured by intervening obstacles, but whose position has been located either by land or aerial reconnaissance. Fire control thus becomes an engineering problem requiring precise instruments, and the effectiveness of modern artillery and, indeed, of the army and the navy, depend greatly on the quality and quantity of these instruments.

In March, 1917, when the imminence of our entry into the war was apparent, the Naval Consulting Board disclosed the critical situation in respect to optical glass. Imported stocks were at the vanishing point, and there was no possibility of replenishment from abroad. This glass, the most refined product of the glassmaker's art, was inherently a secret process confined chiefly to one firm in Germany, one in France and one in England. In each country it was either a government monopoly or enjoyed a subsidy. The fact that all imports of optical glass into the United States came in duty-free increased our dependence on these sources.

In this emergency, the government, through the Council of National Defense, sought the aid of the Geophysical Laboratory of the Carnegie Institution, whose research laboratory had been engaged for many years in the study of silicate solutions similar to optical glass. Dr. Arthur L. Day, director of the laboratory, began an immediate survey of the country's facilities. Dr. F. E. Wright headed a group of scientists which was assigned to the Bausch and Lomb plant in April, 1917.

Here the pioneer efforts of William Bausch, begun in 1912, had resulted in the production of two types of optical glass, but much remained to be done. The government required 2,000 pounds of optical glass per day, whereas 2,000 pounds per month was about the total to be expected from the one producing plant and from the experimental plants of the Bureau of Standards, Keuffel and Esser, Pittsburgh Plate Glass Company and the Spencer Lens Company.

Military optical instruments are for

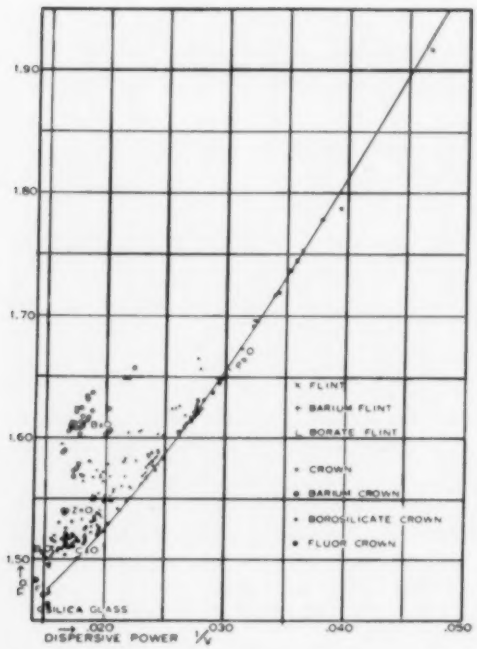


FIG. 1. DISPERSIVE POWERS OF A SERIES OF OPTICAL GLASSES ARE PLOTTED AGAINST THEIR REFRACTIVE INDICES. AFTER WRIGHT.

the most part telescopes or instruments related to telescopes, and experience has shown that from three to five different types of glasses are required in their design. The problem was to perfect a few types of glasses, such as ordinary crown, borosilicate crown, light and dense barium crown and light and dense flint, rather than to develop entirely new types.

War-time efforts in the field of optical glass production were, therefore, concentrated on the problem of producing these few essential types of optical glass, and facilities were developed adequate to meet our needs.

At the close of the war the demand for optical glass was reduced to a very small part of the war-time requirement, and much of the productive capacity of the country was abandoned. The production of optical glass, however, was continued by the Bausch and Lomb Optical Company and at the plant of the Bureau of Standards.

In order to meet the requirements for photographic lenses and microscope objectives, many new types of glass remained to be developed. These have gradually been added to the list produced during the war until at the present time the United States is absolutely independent in so far as concerns the production of all essential types of glass, as well as in the production of the raw materials from which the glass is made.

Limitations of the Old Glasses

While little is known to-day of the constitution of glass, even less was known at the close of the World War. However, analysis of the available types of glass did afford some knowledge of the properties of the final product.

Except for the early attempts of Fraunhofer and the later work of Harcourt and Stokes, no effort was made to break the uniform monotony of crowns and flints until Abbe and Schott joined hands in 1862, although Dolland's achromatic telescope objectives had indicated the need for new types.

It was Abbe's discussion of the limitations placed on the design of refracting instruments by the limited number of optical glasses which outlined the research to be attempted. Beyond silicic acid, alkali, lime and lead, scarcely any substances had been tried except perhaps alumina and thallium. The problem was to produce crown and flint pairs with as nearly as possible proportional dispersion throughout the different sections of the spectrum, in order to afford a higher degree of achromatism than the old glasses, thus diminishing the strong secondary spectrum, and to attain a greater diversity in the two chief constants—mean index and mean dispersion. Because of the uniformity of their chemical constituents, the old silicate glasses could be arranged as a single series in which,

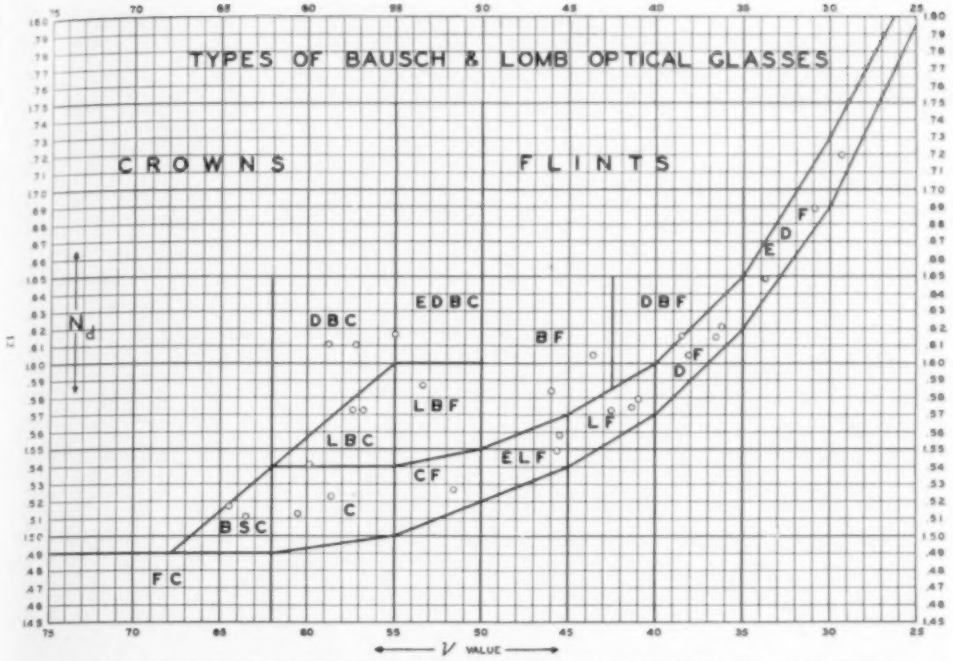


FIG. 2. RATIO OF REFRACTIVE INDEX TO DISPERSIVE POWER IN VARIOUS TYPES OF GLASSES.

FC	Fluor Crown	CF	Crown Flint
BSC	Borosilicate Crown	BF	Barium Flint
DBC	Dense Barium Crown	ELF	Extra Light Flint
LBC	Light Barium Crown	LF	Light Flint
C	Crown	DBF	Dense Barium Flint
EDBF	Extra Dense Barium Crown	DF	Dense Flint
LBF	Light Barium Flint	EDF	Extra Dense Flint

from the highest crown to the densest flint, the dispersion steadily increased with refractive index.

The effort to break the linear relation of the old glasses required the introduction of many new elements and created many difficulties. The flux must not act upon the material of the crucible and so absorb impurities. Elements which evaporated during the melting process, tending to produce "veins," had to be discarded. The glass must be brought from the plastic to the solid state without producing strain. In the operations of melting, cooling and subsequent reheating extreme care was necessary to avoid cloudiness, crystallization and bubbles. Further, the glass must be colorless, strong enough to withstand grinding and polishing and untarnishable.

Properties Sought in New Glasses

Beginning with phosphoric and boric acids as the glassmaking oxides, such elements as boron, phosphorus, lithium, magnesium, zinc, antimony, cerium, didymium, erbium, silver, mercury, thallium, bismuth, uranium and fluorine were introduced in definite percentages. It was soon evident that by the introduction of some of these new elements at least one desired object could be achieved, namely, variation of the hitherto fixed relation

between refractive index and dispersion. Few of these elements, however, were of use in producing a greater similarity between the dispersions of crown and flint.

With the use of boron and barium as the glass-making oxides the relation between refractive index and mean dispersion was radically altered. Boric acid is customarily used in flint glasses for shortening the secondary spectrum, since it has the effect of lengthening the red

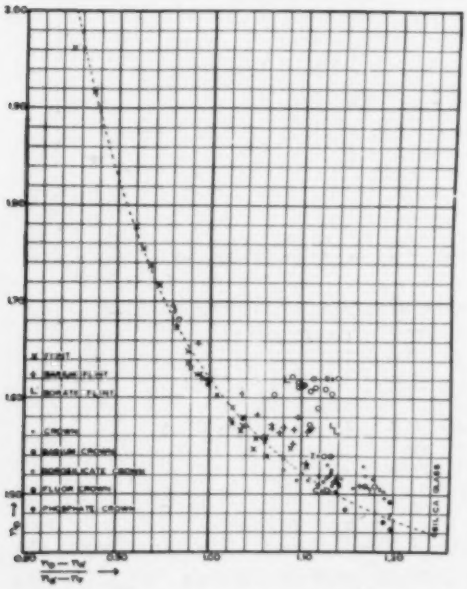


FIG. 3. THE RATIO $(N_D - N_{A'})/(N_{G'} - N_F)$, WHICH IN EFFECT EXPRESSES THE LENGTH OF THE RED END OF THE SPECTRUM TO THAT OF THE BLUE, IS PLOTTED AGAINST THE REFRACTIVE INDEX, N_D, FOR A SERIES OF VARIED OPTICAL GLASSES. AFTER WRIGHT.

end of the spectrum relatively to blue. Fluorine, potassium and sodium have the opposite effect. Fluorine was regarded as a desirable element because it achieved two results; lengthening the blue end of the spectrum relatively to red and lessening the dispersion throughout the middle portion of the spectrum, desirable properties for the part played by crown glass.

If the dispersive powers of the new glasses are plotted against the refractive index, as in Figs. 1 and 2, the old-type glasses fall on a curved line, but the positions of the new types depart widely from this linear relationship. Beginning with the fluor-crown glasses the length of the red end of the spectrum exceeds that of the blue end relatively more than in any other type; following are the borosilicate crowns; then the ordinary crowns, the barium crowns, the barium flints and finally the flints in which the relative dispersion of the blue exceeds that of the red end of the spectrum.

It has thus become possible to select glasses differing appreciably in absolute refringence and at the same time to state their relative dispersions in the blue and red parts of the spectrum.

Photo and Micro Objectives Improved by New Glasses

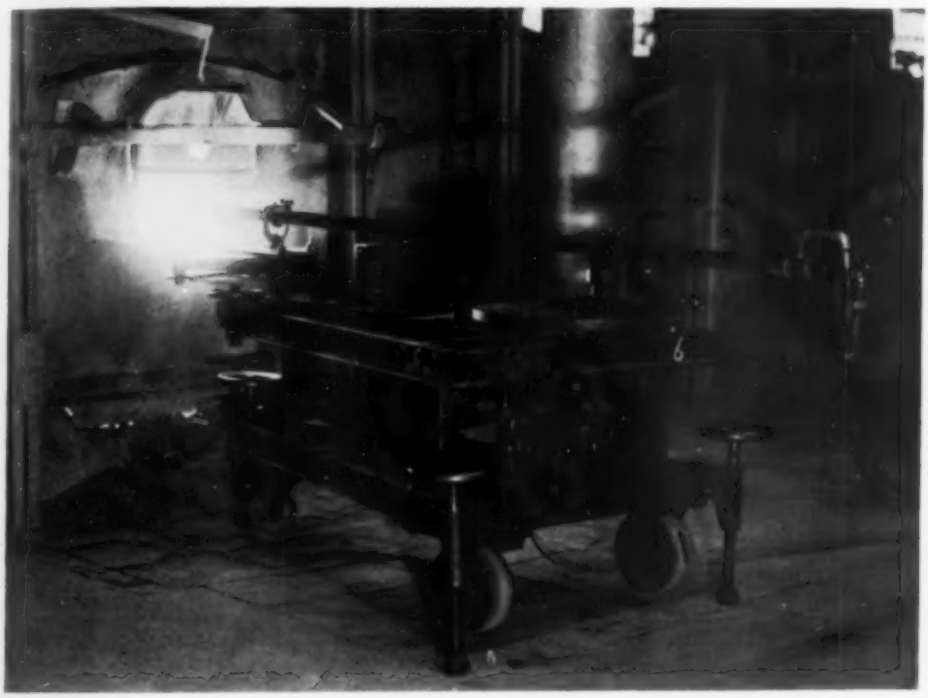
The introduction of new kinds of glass into photographic objectives has made improvement possible in several directions. In the first place, the use of glasses unusually free from color has increased the luminous power of the objective. Then, the similarity of the run of dispersion in the two components of a a doublet has shortened or eliminated the secondary spectrum.

The problem of the simultaneous removal of astigmatism and curvature in the primary and secondary image-surfaces was first solved, though imperfectly, by Miethe's use of phosphate crown and borate flint glasses. In order to obtain anastigmatic flattening, in conjunction with achromatism, it is desirable that the converging lens should have the greater index. This requires that the glass of greater v should also have the greater n, whereas in the old silicate glasses the rule held that the glass of greater v had the smaller index of refraction.

The improvement in microscope objectives, due to the new glasses, is apparent, for instance, in the apochromats. By the introduction of the new borates and phosphates it became possible to achromatize so that only a tertiary spectrum was left. Further, the total dispersion was rendered largely independent of the index. It thus became possible to correct axial spherical aberration for two colors. This result was most successfully achieved by combining the new glasses with fluorspar. In the apochromats the secondary spectrum was abolished and the spherical aberration corrected for two colors. This improvement in quality lessened the necessity for the higher power required in achromatic objectives, in which the smallness of the critical amplification prevented the full utilization of large apertures. An apochromat affords as much detail as an achromat of larger aperture and shorter focal length.

In apochromatic objectives, as in others, the magnification is unequal for different colors, the blue and violet images being larger than the red and yellow. This difference of size can be compensated by a suitable eyepiece. It is only necessary to design the eyepiece so that it has an equal difference of magnification but of opposite sign.

What this has accomplished in photomicrography is suggested by the fact that the most intense visual image is produced by rays from near the red end of the spectrum, while the most intense photographic image is produced by rays from near the violet end. An imperfect achromatism between these two groups of rays makes the two images fall in



MECHANICAL STIRRING OPERATION WITH WATER-COOLED STIRRING ROD.

CENTERING MICROSCOPE OBJECTIVE LENSES.

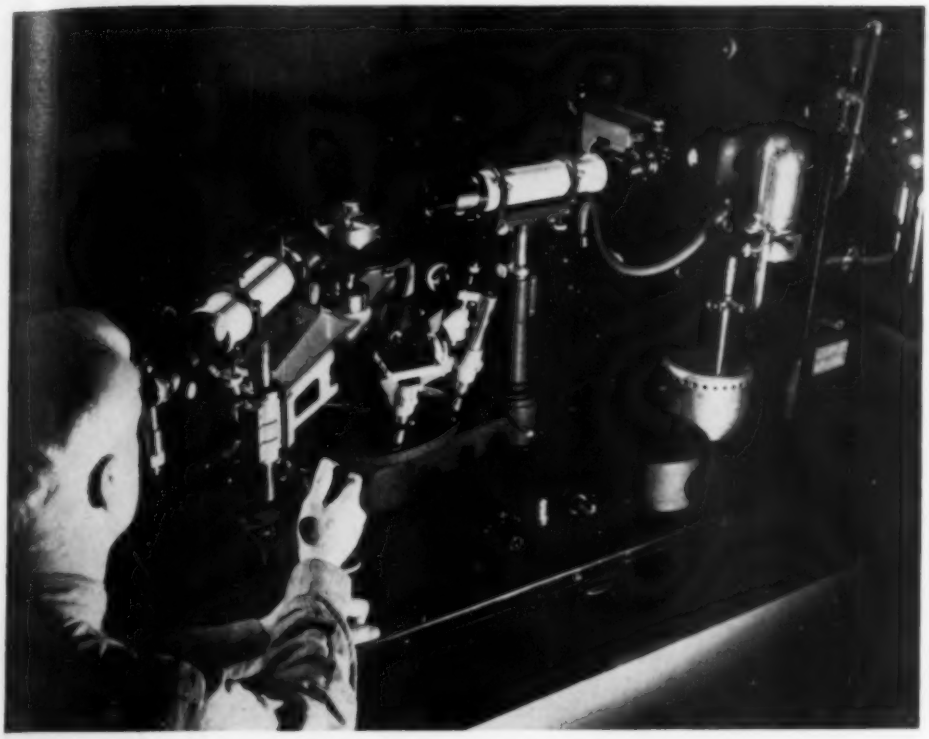
different planes. Focusing thus becomes uncertain and can not be verified by visual observation. With apochromatic objectives, the photographic and visual images are brought into the same plane, and both are equally sharp. Then, since the wave-lengths which are chemically most active are only $\frac{3}{4}$ of the wave-lengths of those which most affect the eye, the resolving power of an apochromatic objective when used photographically should be greater by a factor of 4/3 than when used visually.

Properties More Significant Than Names

The nomenclature used for optical glasses, such as "soft crowns," "high dispersion crowns," "extra light flints" and many other descriptive terms, mean very little, since it is the definite optical properties of each glass upon which the user must rely in prescribing them for instruments.

The glassmaker attempts to produce optical glasses of uniformly high quality with negligible departures from the standards he has set up. This is important because the lens manufacturer can ill afford to change his grinding and polishing tools to cope with changes in optical properties that may occur from melt to melt. To hold the glass within the narrow limits prescribed, raw materials of high chemical purity must be used; furnace temperatures must be carefully controlled; pots must be chemically and thermically resistant; stirring must not be neglected.

Although the glass technologist is rea-



MEASURING REFRACTIVE INDEX WITH A SPECTROMETER

sonably successful in producing glasses of uniformly high quality to close optical constants, the refractive index of a glass type may vary from pot to pot by several units in the third decimal place. First quality glass, however, should be constant in refractive index within several units in the fourth decimal place.

Purity of Pots

One of the chief efforts of glass research in the United States was to secure pots which would not contaminate the melt. The clays originally available contained, on an average, about 2 per cent. of iron oxide, which resulted in an increase in iron content of from 0.02 per cent. to 0.04 per cent. in the finished glass when a wall of one millimeter thickness was dissolved in the glass.

Through the efforts of Dr. A. V. Bleininger, of the Bureau of Standards, and the cooperation of the U. S. Geological Survey, clays and kaolins relatively free from iron and highly resistant were secured. Pot mixtures have now been developed which approach pure kaolin in composition. Extreme care must be exercised in making and drying out pots to prevent shrinkage cracks. Dr. Bleininger also developed a method for casting pots of the porcelain-kaolin type in which waste bisque of white-ware potteries, relatively free from iron, serves as "grog," the composition of the pot closely approaching kaolin. This pot is exceptionally iron-free and excellent for the dense barium melts which have a tendency to flow through the walls of ordinary pots. The use of a magnetic

separator is also employed as an additional protection against too high a percentage of iron in the clays.

Choice of Furnaces

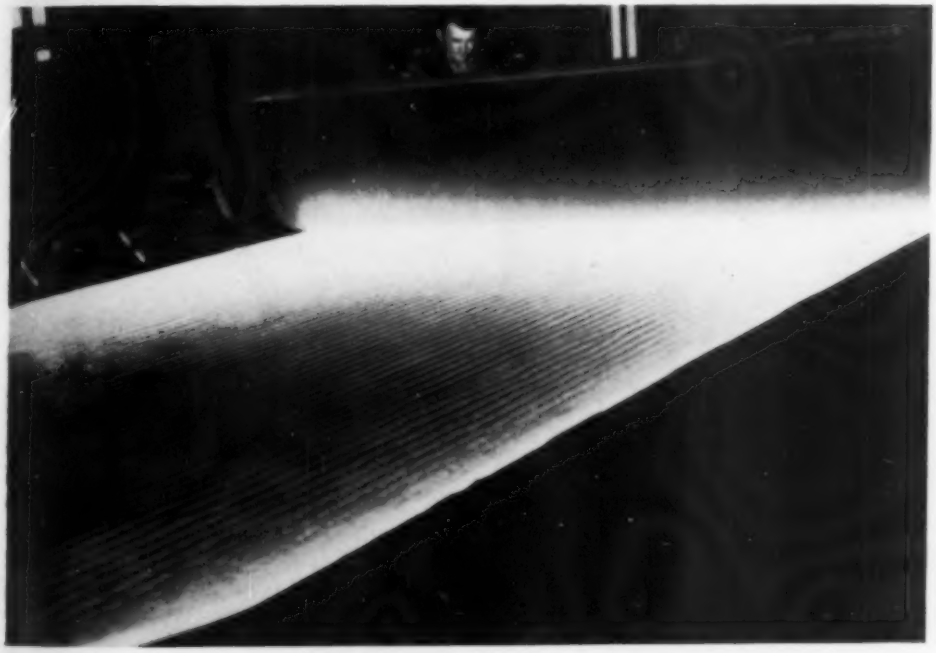
The tendency in the United States has been toward the uncovered pot due to use of furnaces of the regenerative and recuperative types, in which radiation from the crown of the furnace produces more rapid heating and reduces the melting period. Whatever type of furnace is used, however, two factors are fundamental to the production of good optical glass—maintenance of a definite temperature over a long period of time and constancy of temperature distribution within the temperature chamber so that the pot is uniformly heated. To produce optical glass such careful regulation of furnace conditions is necessary that rarely more than a single pot is melted in each furnace. Two-pot furnaces are satisfactory on batches of the same size and composition, but optical glass usually runs to many types and of small quantities as compared to the large quantities of flat glass.

TESTING THE OPTICS OF A NEW RESEARCH MICROSCOPE.

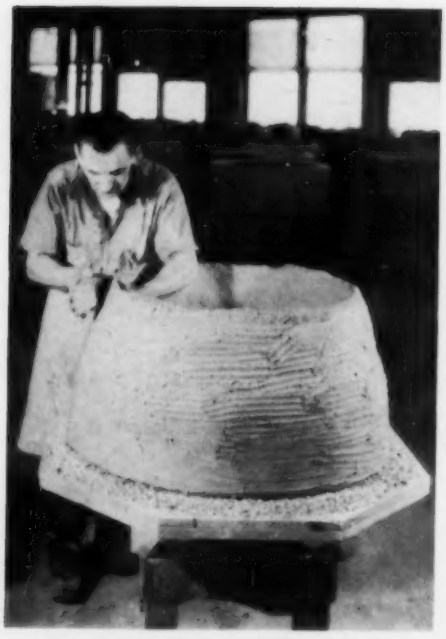
The Batch Composition

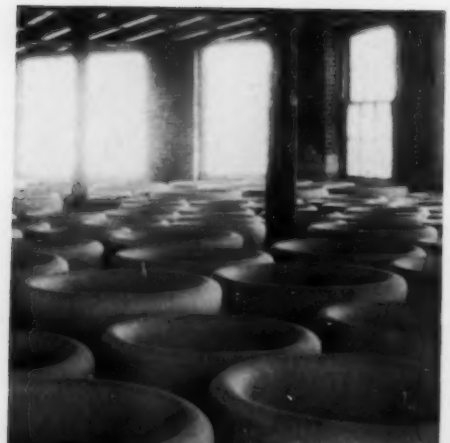
In prescribing the batch composition for a glass of specified refractive index and dispersion, the glassmaker has a number of factors to consider, such as chemical composition and changes of composition that may result from selective volatilization and pot solution. In the series of ordinary crowns and flints, silica, alkalies, lime and lead oxide are

TRANSFERRING PREHEATED POT TO A GLASS FURNACE.



ROLLING A SHEET OF OPHTHALMIC GLASS PREPARATORY TO ANNEALING.





THE MAKING OF POTS.
Above: BUILDING UP A POT BY HAND. *Below:* AGEING FINISHED POTS.

the essential constituents, but the proportions may not exceed certain limits. If silica above 75 per cent. is used, the melt is too viscous; if the alkalies exceed 20 per cent. the glass will be hygroscopic and chemically unstable; if there is more than 13 per cent. of lime used, crystallization takes place and fusing is incomplete; lead oxide may be used in large quantities, possibly 70 per cent. or more, but the danger from crystallization increases.

Boron, barium, zinc and aluminum oxides are the most important constituents of the new glasses. Melts high in barium have a tendency to attack the crucible unless boron and alumina are used, while too much alumina makes the glass so viscous that it is unworkable. Dense barium glasses also require special furnace treatment to secure melts free from bubbles and other defects. The addition of arsenic is often favored because of the increased brilliancy and transparency imparted to the glass.

The batch is charged into the pots as the melting proceeds, and the complete melting and solution of the components is accompanied by an evolution of the volatile components so that the final product is a solution of silicates very nearly free from bubbles. A vigorous stirring of the melt accelerates the solution and melting while reducing the differences in concentration in various parts of the melt.

Stirring for Homogeneity

Stirring was first introduced by P. L. Guinand, an early French glassmaker, who used a clay stirring rod operated by hand. The clay thimble is still used, but to-day it is fitted to the elbow-end of a water-cooled stirring rod, and mechanical means are employed to impart the desired motions to the rod. Good optical glass can not be produced without stirring. It makes the solution homogeneous and helps to remove or

causes absorption of fine or heavy striae. The rate of diffusion is increased, and the heavy concentrates are prevented from sinking to the bottom.

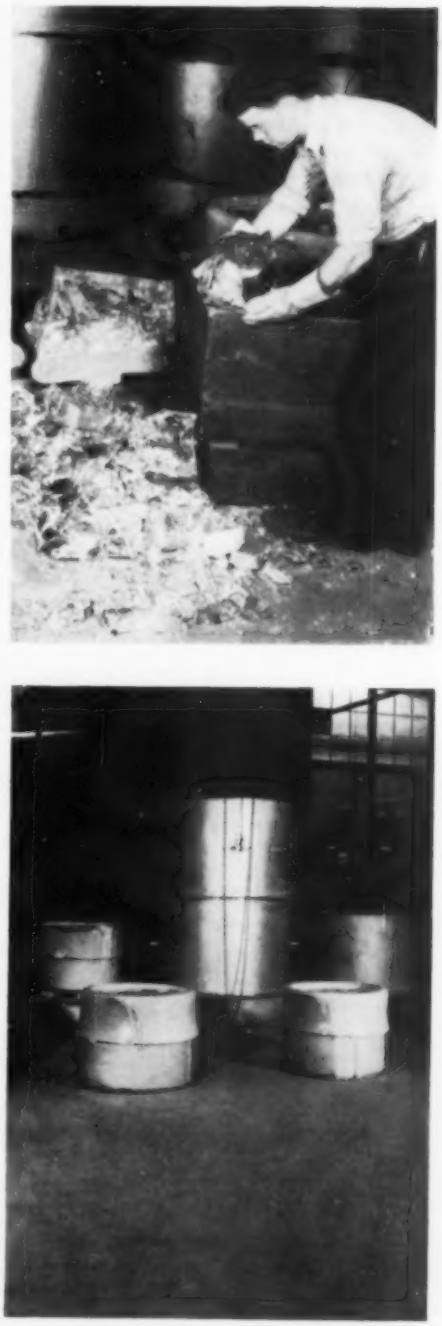
Annealing

Pots of optical glass must be cooled slowly, otherwise crystallites in the surface film may extend downward and form radial spherulites within the mass. When crystallization does occur, it ordinarily begins at the top surface and follows to the sides, due to the fact that volatilization produces a surface richer in silica, which is the primary phase to crystallize out.

The numerous problems that enter into the process of cooling and fracturing a pot of glass are not thoroughly understood. The more important factors appear to be: change of viscosity of the various types with temperature; rates of relaxation of internal stresses at different degrees of temperature; and the temperature distribution within a cooling liquid imposed by the shape and dimensions of the pot.

To regulate the rate of cooling, a hollow, double-walled sheet-iron cylinder, closed at one end, is placed over the pot to retard the cooling rate. The walls are insulated with a diatomaceous earth and the pot is placed in a bed of the same material. A 36-inch pot usually is annealed in three days and a 49-inch pot in five days.

Having cooled to room temperature, the pot is then broken away from the glass, care being taken to preserve all the usable pieces of glass—these rarely amount to more than 25 per cent. of the pot, which accounts for some of the expense of the product. In cracking the pot, ordinarily one or more cracks in the glass appear forming an irregular dividing line suggesting where cleavage can be most easily effected. Before leaving the furnace hall, all the glass is examined for striae, stones, color, bubbles, seed, char-



IN PROCESS OF CARING FOR GLASS.
Above: SALVAGING GLASS FROM A BROKEN POT.
Below: ANNEALING OPTICAL GLASS UNDER INSULATED DRUMS.

acter of fracture, state of annealing, and then sorted to approximate sizes before going to the storage vaults. Pieces at random are selected for measurement of the optical constants and a note of these measurements is marked on the bin and a copy filed for future use. Eventually the glass passes from the vaults to the trimmers, pressers, molders, grinders and polishers. It is again inspected and then returned to the vaults for eventual requisition by optical engineers, who prescribe certain types in the design of optical instruments.

Similarity of the Properties of Optical and Ophthalmic Glass

While a distinction is made in the industry between ophthalmic and optical glass, Bausch and Lomb uses the same pure ingredients for both. Ophthalmic glass is not a cheaper glass, or should not be, but merely a type of optical glass which differs chiefly in the process of annealing, being rolled in sheets on a casting table and sent through a series of annealing ovens. During the process of rolling, the striae, when such exist, are spread out as thin sheets and ribbons parallel with the surface of the plate and hence do not appear after the plate is polished. For many lens elements rolled glass is quite satisfactory because the light passes through approximately normal to whatever mean that may be present, but for such optical parts as prisms, in which the light rays traverse the prisms in different directions, glass free from striae is required and is best obtained by annealing in the pot.

ANALYSIS OF WORLD'S FAIRS' HEARING TESTS

By H. C. MONTGOMERY

ACOUSTICAL RESEARCH DEPARTMENT, BELL TELEPHONE LABORATORIES

ONE of the popular Bell System attractions at the World's Fair was the hearing test. More than a million people, visitors either to the New York World's Fair or to the Golden Gate International Exposition at San Francisco, have taken advantage of the opportunity to find out how well they hear. Many of them allowed the results of their test to be copied, and have thus made possible the widest survey of hearing that has ever been made. Information available heretofore in these laboratories has been based on studies of a few thousand people at most, while the largest previous survey, that of the United States Public Health Service in 1936, covered only about 9,000. In a sense, the Bell System deals in hearing, and if it is to provide the best service at the lowest possible cost, it is important that it have available reliable data on the hearing characteristics of the American people.

The tests are given in sound-proof rooms arranged to seat seven visitors, each partially screened from the others. Both the tests and the instructions are given through telephone receivers which

FIG. 1. A RECORDAK PROJECTOR AT BELL TELEPHONE LABORATORIES
PHOTOGRAPHIC FILM OF THE TEST CARDS MADE AT THE FAIRS ARE RUN THROUGH THIS PROJECTOR AND A GIRL TRANSFERS THE INFORMATION ON THEM TO "PUNCH" CARDS.

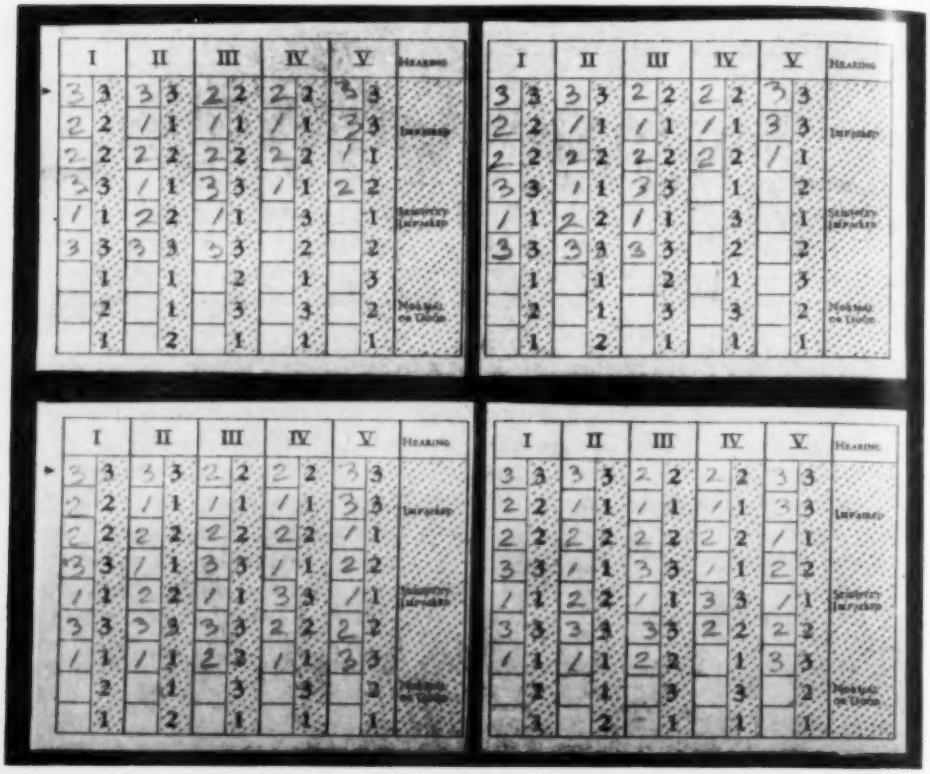


FIG. 2. TEST CARDS AS THEY APPEARED AT CHECKING DESKS AT THE FAIRS AS THEY WOULD BE FILLED OUT BY AVERAGE MEN AND WOMEN IN THE AGE GROUPS 20–29, BELOW, AND 50–59, ABOVE. THE CARDS FOR WOMEN ARE AT THE LEFT, AND FOR MEN, AT THE RIGHT. THE NUMBERS AT THE LEFT OF EACH COLUMN ARE THOSE WRITTEN BY THE PERSON TAKING THE TEST, WHILE THE DARKER ONES ON THE RIGHT HALF OF EACH COLUMN, WHICH APPEARS WHEN THE CARD IS HELD AGAINST A BRIGHT BACKGROUND, ARE THE CORRECT ONES.

the visitors hold to their ear with one hand while they mark the results on a card with the other. Two types of tests were given, with separate booths for each. In one, the visitor hears spoken words, which are two numbers such as "eight-six," and the numbers heard are written on the card. Twelve pairs of numbers are given at successively lower volumes, and then the test is repeated.

In the other type of test, the two numbers are replaced by pure musical tones, each tone being sounded from one to three times, and the listeners write down the number of times they hear the tone. Five tests, each consisting of nine sets of tones at successively lower volumes, are given. The first is at a moderately low pitch, 440 cycles per second, which corresponds to A above middle C on the piano. Each following test is one octave higher in pitch, and thus the hearing is tested at 440, 880, 1,760, 3,520 and 7,040 cycles.

At the San Francisco Fair, there were three booths, one arranged for word tests, one for tone tests and one that could be used for either. At New York eight booths were provided for each type of test. The word test gives a good check on one's ability to understand spoken words, while the tone test, by providing

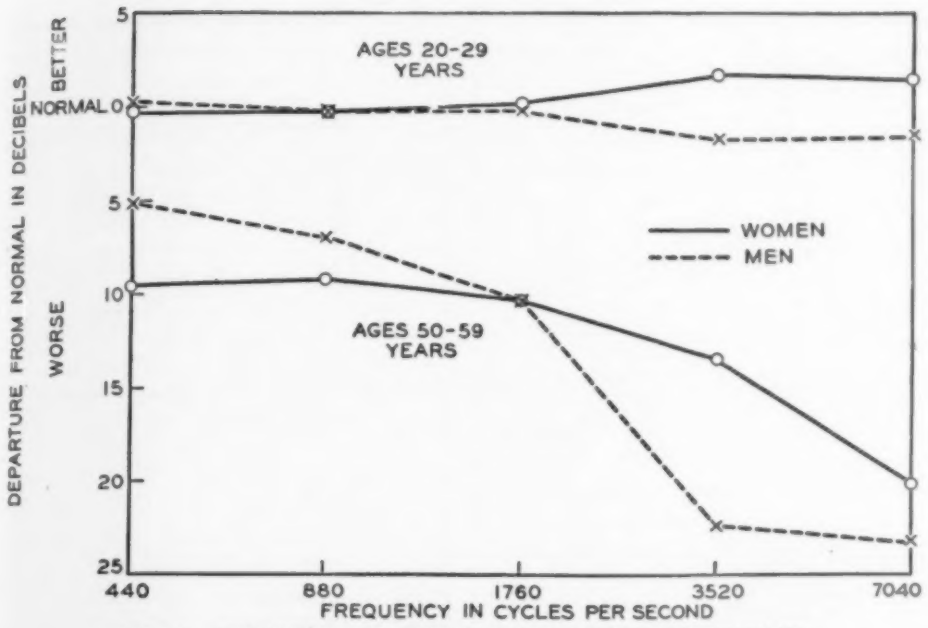


FIG. 3. VARIATION IN HEARING LOSS WITH FREQUENCY

FOR MEN AND WOMEN IN THE AGE GROUPS 20–29 AND 50–59. NORMAL HEARING IS TAKEN TO BE THE AVERAGE HEARING OF YOUNG MEN AND WOMEN WHO DO NOT HAVE ANY OBVIOUS HEARING DEFECTS. A PERSON WHO IS COMPLETELY DEAF WOULD HAVE A HEARING LOSS OF 125 DECIBELS.

data at five frequencies over the most important part of the frequency range, is more suitable for study and analysis.

Before a record is made on the test card, the attendant puts a check on it to indicate whether the visitor is male or female, colored or white, and to which of the five age groups—10–19, 20–29, 30–39, 40–49 or 50–59—she judges him to belong. The record is then photographed on 16-millimeter film with a Recordak machine. At the laboratories the data are transferred to "punch" cards by an operator who views the film in a Recordak projector. The cards are punched to indicate not only the result at each frequency, but the age, sex and color of the subject, and the date and hour of the test. These cards are then run through tabulating machines that analyze and sum up the data.

The results of this survey, in harmony with existing data, indicate a definite falling off in hearing acuity with age. This is particularly noticeable at the higher frequencies. A rather remarkable fact is that at the low frequencies, the falling off with age is less for men than for women, while at the higher frequencies it is less for women than for men. These facts are indicated in Fig. 2, in which average hearing loss is plotted against frequency for the age groups 20–29 and 50–59. For a frequency of 880 cycles, which is next to the lowest frequency in the test, the loss for women in the oldest age group is about 3 db greater than for men, while at the highest frequency it is about 7 db less. For the youngest group the differential between men and women nearly disappears at the low frequencies, and is only about 2 or 3 db at the highest.

The curves of Fig. 3 give the averages only, while it is often important also to know the extent of the deviations from these averages, that is, whether the individuals range widely from the aver-

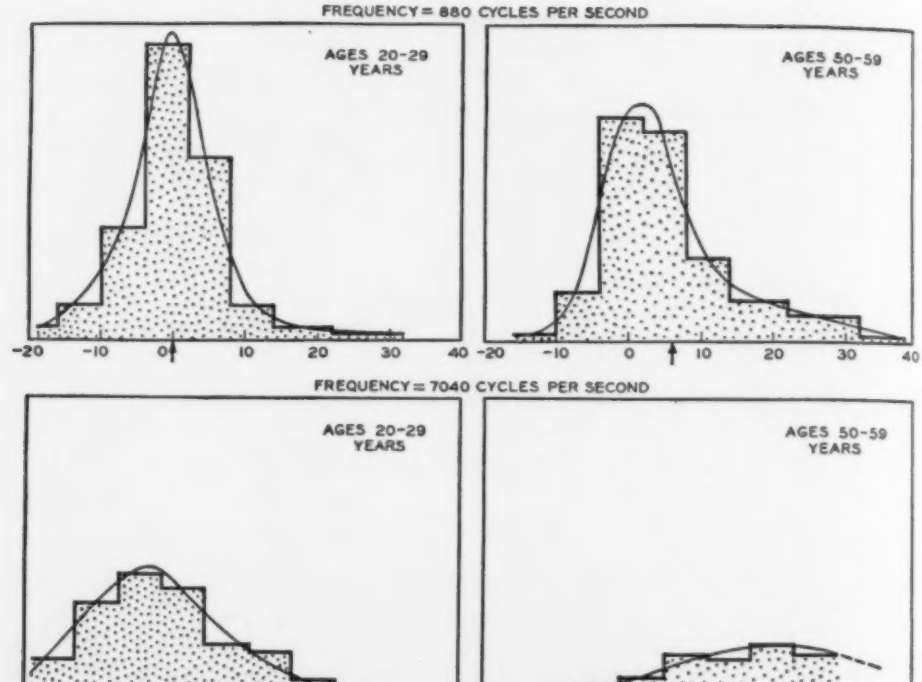

FREQUENCY = 880 CYCLES PER SECOND
AGES 20-29 YEARS
AGES 50-59 YEARS
-20 -10 0 10 20 30 40
FREQUENCY = 7040 CYCLES PER SECOND
AGES 20-29 YEARS
AGES 50-59 YEARS
DEPARTURE FROM AVERAGE OF 20 TO 29-YEAR GROUP IN DECIBELS

FIG. 4. GRAPHS INTERPRETING RESULTS FROM TEST CARDS

age or are closely grouped around it. The distributions of the deviations are indicated by the four curves of Fig. 4. These are plotted from the data for men, but use of the data for women would not essentially change their characteristics. In each case, the area of the shaded sections represents the total number of tests, and the area under each step represents the number that failed at that step on the test. The abscissa scale is the same as the ordinate scale in Fig. 3. The small arrows along the abscissa scale indicate the average for that particular age group and frequency. The curves actually should extend farther on both sides, but since the range of the test was limited, there is no distribution data available above the highest or below the lowest step, and thus the curves can not be plotted. That they extend a considerable distance in some cases, however, is indicated by the positions of the arrow—particularly for the 50–59 age group at 7,040 cycles. The arrow is near the right-hand end of the curve because a large number of cases lie beyond the distribution shown. The light curves are drawn to indicate the general form of the distribution curve. From these curves it will be noticed that for young ears and low frequencies, the tests are grouped fairly closely around the average—very few falling more than 15 db away. For older persons or higher frequencies, however, the distribution spreads.

Not all the cards have been tabulated as yet, but as additional tests are examined, they are found to fall in line with those already tabulated, and so there is little likelihood of any major change in trend being encountered as the tabulation proceeds. The interpretation of the losses at various frequencies is rather

difficult except for specialists, since the evaluation of the effect on one's ability to hear in any particular band of frequencies is a function of many factors. It has been found, however, that one's ability to understand speech can be determined from the average of his hearing losses at 440, 880 and 1,760 cycles as compared to good young ears. If this average is 25 db, there may be some difficulty in hearing in auditoriums and churches, while if it is 45 db, there may be difficulty in hearing in direct conversation. Only if it is as much as 65 db will there ordinarily be much difficulty in hearing over the telephone.

By use of these figures, the tests indicate that about one out of twenty-five persons have difficulty in hearing in auditoriums; one in 125 will have some difficulty in direct conversation; and one in 400, over the telephone. Two out of five men between 50 and 59 will have a loss of at least 25 db at 3,520 cycles, while only one in 5 women—half as many—will have as great a loss at this frequency. It was found, also, that about 1 in 25 of the group from 10 to 19 had a loss of at least 25 db at 7,040 cycles. This figure is significant because otologists have found that young people with a hearing loss of this amount will often tend to become progressively worse in later years, but that if remedial measures are taken, the hearing impairment may be largely checked.

It should be kept in mind that these proportions apply to the records obtained at the fairs. They can not be applied to other groups or to the population at large without considering differences in age distribution, economic status, nationality, and other similar factors. For example, the proportion of people over 50 in the population is considerably greater than among the fair visitors, and it is estimated that this fact would nearly double the percentage having a loss of 25 db at the lower frequencies. It is also necessary to consider to what extent the hearing records obtained represented a fair sample of the visitors to the fair. A study of these problems of interpretation is now in progress.

During part of the summer, visitors at each fair were asked to indicate whether they lived in the vicinity or not, so that information would be available to determine sectional differences in hearing acuity. Studies of these answers, however, do not reveal any significant difference between New York and San Francisco. The time of day at which each test is taken is marked on the card by the attendant, thus permitting a comparison of the results for different periods of the day. No consistent difference has been found, however, even between early morning and late afternoon. There is thus no indication of any effect of fatigue on hearing.

ORGANISM, SOCIETY AND SCIENCE

I. ORGANISM

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THIS essay, in two parts, is an attempt to evaluate the deeper significance of science for the society in which it is embedded, by approaching the problem through the essentially biological conception of organism. Now, more than ever in the past, it is urgent that scientists give thought to the human consequences which flow from their activities.

UNIT AND WHOLE

The concept of organism, as a semi-independent unit system composed of lesser units in interrelation with one another, need not be developed here. It applies to solar systems, snow crystals, atomic nuclei, and football teams no less than to micrococci, maple trees and men. Animate organisms constitute a subclass in this broader category, sharing the general attributes and adding their particular ones; and it is these I wish especially to consider. Unfortunately, no differential terms exist for the entire class and for those subclasses of organisms which are living individuals or for those which are not. Perhaps such words as "animorg" and "inanimorg" for these respective groups will prove useful additions; but for the present I shall use "organism" in the more restricted sense of an individual *living* organism.

That the demarcation of living from non-living is fuzzy and sometimes arbitrary, I am well aware; yet over most of the range the differences are clear enough (though sometimes practically undefinable), and it would serve no present purpose to scrutinize the transition zone. The extension of the attributes we find for organisms to societies of them—to epiorganisms, as I propose to call these—is, on the contrary, a central theme of this essay; and the justification for this will presently be examined.

An organism, whether uni- or multicellular, possesses three major attributes: it is in open dynamic equilibrium; it performs specific synthesis; and it manifests adaptive amplification. The first is concerned with the maintenance of the living machinery, with the steady flow of substance and especially of energy through the system, which is necessary to preserve or perpetually renew its highly improbable architecture; facing, as it does, the forces of disintegration and the second law of thermodynamics. Its peculiar substances, especially the enzymes and related catalytic molecules, and its peculiar organization, especially the electrically charged colloids and membranes, must be retained or renewed, howsoever that uninterrupted process of change, which is living, swirls about them. The physico-chemical flame is commonly called metabolism, the fuel being supplied by digestion and absorption and the oxygen by respiration, the burned wastes being removed by excretion, and with a moving fluid contributing to the transport of substances about the larger individuals. Whether by elaborate organ systems or by relatively undifferentiated protoplasm in the single cell, these various functions are discharged and the organism is enabled to persist as itself, a particular system in approximate dynamic equilibrium.

Superimposed upon this rapid and relatively stable process is a slow directional drift of the whole equilibrium, for growth punctuated by reproduction is as

universal as maintenance. Increase in mass (growth) or number (reproduction) or complexity (differentiation) requires the manufacture, out of protean and simple crudes, of the particular substances (and patterns) present in and partly unique to the individual. This specific synthesis is, of course, related to the constructive aspect of metabolism but can not simply be equated with it. The mechanisms for building the living machine—by autocatalytic enzymes and gene duplication, by chromosome apportionment and cell division—vary but little from the simple to the highly elaborate organism. Only the devices for the reproduction of multicellular individuals are introduced and elaborated at successive levels of evolutionary change.

The behavior of organisms, the running of the living machine, shows the greatest variation from one kind to another, though still basically alike in all. Some environmental change, acting as a trigger, elicits a response by the organism which releases more, often incomparably more, energy than was contributed by the stimulus. Further, this amplified energy release is directed in such a manner as to remove or counteract the disturbance and to reestablish equilibrium within the organism and to adapt it to its surroundings. Adaptive amplification thus depends on irritability, on some sort of spread of excitation within the organism, and on a final response by appropriate parts. Evolution has led to "advance" most clearly in this attribute of organisms; for the "higher" organisms differ most from the "lower" in that, because of specialized receptor elements, they are more sensitive to more types of stimuli; and, because of specialized effector and conductor elements, they perform more elaborate and coordinated actions more rapidly; and, because of specialized portions of a coordinating nervous system, they manifest greater latitude in the kind and interval of response to given situations, to the extent that there is a strong appearance of choice and initiation of action.

Metabolism and growth may be as adequate in the single primitive cell, even in the cell removed from a multicellular unit, as in the highly elaborate primate, but behavior is not. Adaptive amplification is associated with the organism as a whole, and so is especially a function of its total organization. And so we shall return to living things as organized systems and to some consideration of organism in its broader connotation. May I use the term "org" to denote this inclusive sense of organism?

An org has persistence in time and boundaries in space, both of which may be short or ill-defined. During its recognizable integral existence, however, or during some differential segment of it, the org endures in approximate equilibrium. Within it there exist interactions between parts and between part and whole which also endure as constants. True, the mechanisms of coordination may themselves be dynamic equilibria, as we shall see, yet in intergrating the parts into the whole, the lesser orgs into the greater one, they are essentially static forces independent of time's arrow. The point has sometimes been made that when some event is most clearly related to an antecedent one the latter is spoken of as its cause, when to a subsequent one, it is called its purpose. This might be extended by the statement that when two or more events are clearly related contemporaneously they constitute an org.

This raises the vital problem of the character and direction of the determination or control or correlation or causation or force, as you will, acting between part and whole. As to direction and degree, the possibilities are limited; either the constituent unit or the org may determine the other partly, completely, or not at all. If neither determines the

other at all, there is clearly no org but rather chaos. If each determines the other completely, there results a closed isolated system; only the entire universe can qualify as such. If determination is complete in one direction, say the org is fully controlled by its units, then the system can be externally influenced only at the unit level, that from which control is directed; and, in effect, the reciprocal direction of control is non-existent. But this is tantamount to denying organization, for the essence of an org is that the units in it act differently from solitary ones by virtue of their incorporation in the system. As Whitehead has said, "an electron blindly runs, but within the body it blindly runs as conditioned by the whole plan of the body." Within the atom it runs in circles, outside it in straight lines. It follows, then, that determination between the org and its units is always reciprocal and always partial and that the system can be modified by the environment acting upon it at either level. But enormous quantitative variation is possible within this frame, as is clear from a study of organisms.

The living cell is, or course, an org, and one of a high order; for its constituent units are orgs, *e.g.* collodial micellae, and their units are orgs, *e.g.*, protein or lipoid molecules, and so on for a regression through several levels. It may also be an organism, one of the unicellular protozoa or protophyta, or it may be a unit in an org of still higher order, a multicellular organism. Indeed, the cell which is a unit in an organism may be a more elaborate org than one which is itself an organism—compare a nerve cell from the mammalian cerebrum with a micrococcus—but perhaps our present needs will be served by an analysis of the relation between a cell and an organism, as a clear example of the more general relation between a unit and its org.

At once terms are indeed to connote differences between orgs of the same order, terms analogous to "higher" or "lower" as applied to organisms. I shall use "integrated" for this distinguishing property and refer to orgs as highly or poorly integrated, or as differing in integration. This will refer primarily to the final step, so that an org of order $N+1$ may be composed of highly integrated units of order N and yet be poorly integrated. The sponge, for example, is such a case; it is a poorly integrated organism containing highly elaborated cells. It is perhaps obvious now, and will become more so, that as the integration of an org increases the determination of the unit by the whole also increases relative to that of the whole by the unit. That is, the balance of control shifts from the cell to the organism as we pass from the lower to the higher (and more recently evolved) forms of living individuals.

Mechanical Correlation

Since organic evolution presents us with a rich spectrum of organisms for study, the intraorg determinants can be particularly well analyzed in this field. Perhaps simplest are the mechanical and geometric relations. An active muscle cell changes its shape anisotropically, the muscle shortens and thickens, exerts a tension through tendon on bone, and this, usually acting as a lever, causes gross movements. Conversely, the development of muscle, composed as it is of thousands of cells oriented as long spindles or cylinders parallel to each other and along the tension axis, depends in considerable part on the existence of a stress in the tissue. When a muscle's tendon is freed and the stress removed its cells degenerate. Bone cells similarly accumulate in the spongy interiors of bones so as to deposit their calcareous spicules along lines of stretch and compression. A median section of the femur is a perfect engineer's stress-strain dia-

gram drawn in lines of calcium salts. And the stress determines the cell behavior, for when a broken bone sets at some abnormal angle, the old spicules are destroyed and new ones are laid down in accord with good engineering practise. Further, from one animal to another closely related one the leg bones do not simply follow in their linear dimensions the size or weight of the animal. A doubling in linear dimensions would increase volume and weight eight times, or as the cube. But since the resistance of a bone to crushing decreases with its length and increases with its cross section, to support an increase in weight the leg bone must become relatively more chunky, increasing in diameter more than in length. And so it does—compare the legs of the heavy percheron and the light thoroughbred, or of the gazelle and the elk.

Or consider the hydrostatic and dynamic consequences of blood pressure and flow. The entire circulation of the blood is based on the mechanics of that good pump, the heart. By the flow in the capillaries and by the filtration of fluids through their walls due to blood pressure, the tissue cells are kept freshly supplied with nutriment. A maintained excessive blood pressure may cause multiplication and hardening of the cells in the vessel walls, arteriosclerosis; but excessive pressures can not normally persist any considerable time, for the stretch of certain receptors in arterial walls initiates reflexes which slow the heart, dilate the vessels, and reduce the pressure. This last example involves, of course, another coordinating mechanism, the nervous system, as well as the mechanical one—but such interaction is the rule. A like case is the throbbing pain from an inflamed tooth, the vessels of which swell with each pulse as it compresses the nerves between bony walls.

In less integrated organisms such mechanical factors as blood pressure and muscle tension, even gravity, decrease or vanish but others become more prominent. The shapes of cells are partly determined by the pattern in which they are packed together—polygons, spheres, cuboids, pyramids, cylinders, spindles, plates, etc., are formed in harmony with the configuration of the tissue. In some very lowly multicellulars, as slime moulds or a number of the algae, this packing effect of juxtaposition is almost the only factor relating the individual cells with one another.

Within the single cell, alone or in a group, the dominating mechanical factor is surface tension. Not only does this contribute importantly to shape and to movement but also to cell size and division. Since the compressive force exerted increases as the radius of curvature decreases, too small a droplet may be, so to speak, squeezed to death and too large a one may fall apart.

It is important to note two points illustrated by the foregoing examples. First, as we pass from less to more integrated organisms the variety and magnitude of the mechanisms operating between the individual and its cells increase, especially in the direction from org to unit. Second, though the same general control exists in orgs of different order it may operate through quite different machinery. Surface tension within the cell and gravity or blood pressure within the many-celled organism are all mechanical forces; but it would be fatal to extrapolate from integration within the cell to that within the large organism. These generalizations apply in even greater degree to other means of control, especially that of transmission.

Transportation Correlation

Chemical factors of coordination, or more generally transportative ones—since heat, for example, as well as particular substances, may move from place to place

—are of great importance. In the simplest cell, a unit or an organism, molecules move through the protoplasm by their own kinetic energy and diffuse from a region of greater to one of lesser concentration. En route they may be blocked or retarded by membrane barriers which are completely or partially impermeable to them, or they may enter into chemical reaction and be lost.

Since the amount of oxygen, for example, required by a cell increases in proportion to the volume of its protoplasm, or the cube of its radius, while the surface through which this gas must enter increases only as the square of its radius, transport by diffusion soon limits the possible size that a cell may attain. Further, the time required for diffusion varies not with the distance to be traversed but with its square. It is not surprising, then, that as cells reach large sizes—some simple algal cells are several millimeters in diameter—diffusion becomes inadequate. The protoplasm becomes spread as a thin layer within the outer membrane and the core of the mass is composed of a "sap" of simple salt water which is kept stirring around by still unknown means. How much more important must transportation become in multicellular organisms!

Part of a single cell, severed from the rest so that the cell nucleus is not included, dies; but as little as one thirtieth of the cytoplasm, containing the nucleus, may live and regenerate the lost portion. The nucleus is thus essential to the maintenance of other cell parts, whether the cell is itself an organism, as in the case of an adult protozoan or the egg of a metazoan, or is part of an organism, as in the case of a nerve cell. This latter is particularly striking, for the fine fibre of a nerve cell may stretch a meter or more from the nucleus-containing cell body, and it receives its independent blood supply, yet it dies when the tenuous connection is cut. There is evidence here that substances (enzymes) elaborated in the nucleus spread to the far ends of the cell with the aid of peristalsis-like movements in the protoplasm.

Such chemical factors of coordination within the cell are extended and elaborated in the many-celled organism. A mere clump of initially like cells must acquire the rudiments of organization at the multicellular level as a result of their spatial arrangement and the diffusion situation, for the inner ones are partially cut off from the free exchange of materials with the outside world by being buried under the outer ones. Their rate of activity is consequently less than that of the more favorably placed units, and this quantitative differential is an org determiner. This aspect will be further elaborated shortly as the basis of the highly important gradients in orgs.

In more integrated organisms transportation is improved and new chemical coordinators are introduced. The sponge drives a current of sea water through its open structure by the beat of flagellated cells. The plant moves water up its woody tubes by osmotic and other action of its roots and by evaporation from its leaves. The flat worm churns a mixture of partially digested food and water about its widely arborized gastro-vascular cavity. The crab has a true circulating body fluid pumped to the cells through tubes by a crude heart but seeping back through the loosely knit tissues. In the vertebrates we encounter a fully developed vascular system and efficient heart which sends the blood systematically about the entire body. The time required for fresh fluid to move through the body and be renewed about each cell is progressively diminished despite the ever greater distances; in man, arterial blood is steadily rushing through the capillaries, and perhaps half a minute completes the whole body circuit.

Also, with improving integration, the composition of the circulating medium is

ever more elaborate and, even more important, more constant; so that most cells are, in effect, no longer exposed to the external environment at all but to a made-to-order internal environment. Their growth, state of action, even the direction in which they differentiate, are extensively controlled by this chemical milieu. A change in the salt proportions of blood can speed or stop the heart, send arm and leg muscles into spasms or paralyze them completely, act on the brain to given delirium or coma, and the like. But alterations of such magnitude are normally prevented by the action of liver, kidney, and other organs. A slight change in carbon dioxide content can cause violent or suspended respirations, and a rise or fall in blood pressure, and this gas also helps to modulate the supply of blood to any tissue or organ by dilating or constricting the blood vessels serving it.

Here, in fact, is a beautiful example of interaction between org and units. Only by maintaining a constant head of pressure in the whole system can the blood supplied to any one cell be regulated to its needs. As a cell or cell group becomes active, it requires more food and oxygen; but with increased activity it produces more carbon dioxide, which opens the vessels to it and so establishes the greater supply. But if too widespread local dilation occurs, blood pressure falls and all cells suffer. Other mechanisms, neural in character, protect against this under normal conditions; and under extreme stress or deprivation, when not all cells can longer be adequately supplied, the mechanisms even break down in an orderly fashion, for the heart and brain are properly nourished to the bitter end, long after gut and muscle, etc., have been deprived of their sustenance.

Not only are the more universal constituents of protoplasm held in constant or properly modulated concentration in the *milieu interieur*, but a whole new set of chemicals, the hormones, has been added in the higher organisms. These substances are transported in the moving medium and control the action of few or many kinds of cells other than those which form them. Growth substances pass from the tip of a shoot and make the cells along the stem elongate; acid in the upper part of the gut releases into the blood a hormone which excites pancreatic secretion; from the thyroid comes an internal secretion which makes a tadpole's tail shrivel and its legs sprout; from the hypophysis is released one substance which matures the sex glands and another which sets off the thyroid. Again it is clear that, as an organism becomes more integrated and its parts more interdependent, more substances of more powerful or specific action are transported more rapidly and under better direction. Further, the machinery of transport may be widely different at the level of the cell and at that of the metazoan organism.

Transmission Correlation

A third type of integrating mechanism in organisms is transmission, and the machinery for achieving it shows the widest range of all organismic devices. Transmission depends on the passing on of energy, or better of an excitation which sets off successive local sources of energy, rather than on a transport of molecules. Waves in water, light and other radiations, electric currents, produce effects at a distance from their origin by transmission. A spark burning along a fuse is similarly transmitted—at each region the heat generated by burning ignites the next stretch, but no molecules move along the wick.

The nerve impulse, like the spark in a fuse, propagates excitation. Electric currents rather than heat pass between an active and a not yet active nerve element; the current acts on the latter

to produce chemical and membrane changes; the resting portion thus becomes active and helps initiate the same sequence beyond it. Nerve cells and their cable-like extensions are an advanced evolutionary achievement, making transmission far more efficient, but in essence the same process occurs in all protoplasm.

When a sperm fertilizes a sea-urchin egg, a wave of change radiates out from the point of penetration over the entire cell membrane. This can be followed visually, since a fine pellicle is raised as the wave travels and is seen to require nearly half a minute to travel a tenth of a millimeter to the far pole of the droplet. When the tip of one "finger" of a sponge is pricked, a "message" slowly creeps along the animal causing the pores to close over a distance of centimeter or less. The transmission is faster than in the egg, perhaps a centimeter a minute but, since it dies out as it travels, more distant portions of the animal are very little affected. This org is poorly integrated indeed.

The jelly-fish possesses primitive but unquestioned nerve cells scattered in its mass which, making casual contact with each other's processes, form a loose net. When any part of the animal is stimulated, excitation travels in all directions over it and the whole organism responds as a unit. Conduction in this organism is greatly speeded up along the special nerve highways to as much as ten centimeters a second, and it can travel for unlimited distances—500 miles round and round a ring cut from the periphery of the umbrella. Further, the energy of the stimulus required to elicit a response of the animal is greatly reduced, for specially sensitive receptor cells, the touch organs, have appeared; and the response is more rapid, powerful, and adaptive, for specially constructed effector cells, the muscles, are also added.

In the earthworm, nerve cells are clumped together in ganglia, the beginning of a central nervous system, and connect with each other in formal and regular patterns. Transmission may be at a rate of a few meters a second, is unlimited, and is no longer randomly directed. The anatomical connections determine set behavior patterns, or reflexes, and particular muscles are excited from receptors at particular locations. Further elaboration, in the vertebrates, results in a complex continuous central nervous system with peripheral nerves making well-defined connections to receptors and effectors. Nerve impulses sweep along at rates over 100 meters a second and the courses they take, while limited by the anatomical possibilities, are determined to a considerable extent by the functional states of several alternate pathways. This element of modifiability progressively increases to the human nervous system with its relatively enormous cerebrum.

Important and progressive changes occur in the central nervous system, once it is established, as the organism becomes more highly integrated. The jelly-fish has no centralized nervous system, the flat worm and more evolved phyla do have one. The former has a central body axis with respect to which its parts are arranged in a radial symmetry; the latter are bilaterally symmetrical about a central plane along which lies the nervous system. Further, the whole animal, and its neuraxis, is polarized parallel to this plane so that there exists a more active head end which takes the initiative in behavior and a more passive tail end which follows after. The elongation of the body, the anterior-posterior differential, and the central nervous system arise and develop together.

The more stimulated cell or portion of the organism becomes more active. How this comes about we need not inquire here, but the generalization is very widely true and can be observed under all sorts

of test conditions. In a roughly radial animal a temporarily more active sector would tend to lead and become the front end during movement—as frequently a larger arm of a starfish drags the clumsy animal in the direction that it points. But the front end gets most of the bumps, is differentially more stimulated, becomes ever more active and dominant, and so more steadily the leading end. So, presumably, have the actual gradients of activity—measured by quantitative differences in metabolic rate, sensitivity to poisons, and speed of movement, along the anterior-posterior axis—come into being in all bilateral animals.

Now such quantitative gradients are not, *per se*, dependent on any nervous system, for they are present and important in plants and axiate animals which have no nerves. But since they are intimately bound up with excitation, it is not surprising that the nervous system and sense organs are especially concerned with them. The main receptors develop in the head end, those distance receptors (as the ones serving smell, hearing and vision) which give information of the environment before it is encountered, exclusively so; and the nervous system follows after. The receptors are at the apex of the pyramid and come to dominate the entire organism.

This effect is seen most immediately in the central nervous system. Not only does the anterior, or cephalic, end of the nerve stem dominate the remainder, but the entire organ comes to be located ever more forward until the separate ganglia become clumped together well in front of the body segments they still innervate. Far more important, this segmental nervous system, each part still functioning primarily for the control of its own body segment, is supplemented with suprasegmental structures which deal with the whole organism. These new structures arise from the particular portions of the nervous system which receive nerve impulses from the distance receptors, the cerebellum from those of balance and hearing, the cerebrum from those of smell and vision.

These cortices clearly represent a development in response to the organismic need for adequate and integrated response to the ever more numerous and differentiated sensations delivered by improving receptors. Information about the outer world arrives in greater profusion, with finer discrimination, with more alternatives of import, and hence there is need for an improved machinery for selecting, evaluating and integrating it and for deciding on the single total response or individual behavior. The cerebral cortex increases in absolute and relative size as animals ascend the scale, and the response of the whole organism, as a single unit, to its environment is more elaborate, variable, intelligent and unified. In short, the cerebrum, almost uniquely, is the center of integration of adaptive amplification or behavior.[1]

A further word is needed concerning gradients in relation to coordination within the organism. These intensity gradients represent a regular progressive change in some quantity with a similar progression in distance along the body axis. But particular kinds of cells and organs are also located in regular sequence along this axis. Hence the probability arises that the structures determine the intensity, or vice versa. It does

[1] Transmission, and a part of the nervous system, the visceral or autonomic system, comes also to supply important intraorganismic controls comparable to the other mechanisms earlier outlined. The internal reflexes controlling blood pressure have been referred to; similar elaborate sets, always in pairs the members of which oppose each other and so insure fine control, regulate the action of each organ system—respiratory, digestive, excretory, etc.,—in terms of itself and the others. Body temperature depends, for example, on nervous control of skin blood vessels, sweating, hair erection, muscle relaxation, breathing rate, water distribution, etc. This also finds a social counterpart.

not seem probable that organs would chance to be ordered from head to tail in such sequence that each had a lower metabolic rate than the one before it, but it seems even less likely that the metabolic rates of certain cells should determine which organ they will become. Yet something close to the latter is true—morphology is often determined by metabolic rate, not the absolute rate so much as the rate relative to that of other regions in the whole organism.

The evidence for this conclusion is clearest in experiments on regeneration of flat worms. When such an animal is transected somewhere near the middle of its longitudinal axis, the cells at the cut end of the anterior piece regenerate into tail structures, those at the cut on the posterior piece form into a new head. Since it is entirely a matter of chance whether any particular group of cells near the section was incorporated into anterior or posterior half, but it is fully determined by their position whether they become head or tail, it follows that the course of their differentiation is controlled by their relation to the other cells in the piece. Actually it is known that cells at the high end of a gradient will develop toward "headness," including sensory and brain structures; those at the low end, toward "tailness," including digestive elements.[2]

Here then is a completely static determiner, the gradient (itself depending on rates of change which are steady equilibria) which molds units in structure and function by virtue of their location on a quantitative scale in the whole org. This was seen in detail in the nervous system, which actually "migrated" toward the head end and which, being kept near the top of an activity gradient by steady excitation from sense organs, developed the dominant and characteristically organismic cerebral cortex.

[2] The picture sketched is extremely simplified, for not one gradient but three or four general ones operate along the coordinates of symmetry, and these are further supplemented by more local "fields" diminishing circumferentially with distance from a dominant center. The morphogenesis of any cell is, then, the resultant of these many, sometimes partially conflicting, gradient relationships rather than of any single one. It is necessary to introduce these complexities now to show later the parallel with the individual when subjected to multiple social influences.

Cell-Organism Relations

By means of such mechanisms, then, a group of cell units becomes ever more of an organism, less of a mere collection. A more integrated organism, compared to a less integrated one, has more kinds of cells which are largely more differentiated and therefore interdependent. Each cell alone has lost much of its original heritage of totipotentiality for doing and becoming—cells sacrificed their immortality, self-sufficiency, many of them even parenthood, in becoming part of a metozoan—in exchange for some one expertness of function and one elaborate structure. The problems to be solved by the organism are distributed among specialized units which are individually skilled, each for its own task, and which depend completely on mutual cooperation for their own survival and that of their organism.

This progressive interdependence is seen especially clearly in the matter of survival after injury, and in the repair or regeneration of lost parts. The sponge can regenerate from one or a few cells; the flat worm, from a moderately sized piece of the body, say an eighth; the crayfish dies following any major insult to its body, but can still regenerate an eye or leg; the mammal can not replace any lost organ, but certain tissues—skin, connective tissue and blood, some glands—can still grow and repair after injury. The sea-urchin egg, still undifferentiated and an org of very poor integration, can regenerate when only 5 per cent. is left; the adult vertebrate (less so the echino-

derm), a well-integrated org, is promptly killed by any extensive amputation or even wound.

The organismic mechanisms for bringing about this cooperation are, like the units, progressively elaborated, specialized, multiplied and, particularly, strengthened. It is customary to note conflicts in nature, the struggle for survival and ruthless competition among living beings. What is often overlooked is that cooperation, mutual aid, individual sacrifice for the larger group, are perhaps even more wide-spread and are the fundamental biological "virtues." They are virtues in a strictly objective sense and on the same criterion of fitness and adaptation, for they have a high survival value. At every level—within the single cell, the colony, the simple or elaborate multicellular individual—differentiation of parts and their cooperative integration into a whole gives the possessor real advantages over his more homogeneous competitors.

A further word on self-sacrifice for the common good will help emphasize this aspect of living units. When the lobster is caught by its claw, it sheds the appendage, escapes, and eventually grows another. But the claw dies. The organism, by a sort of voluntary act, here sacrifices a part; the latter has little control over events. When, however, a mammal is subjected to cold, the blood vessels in the skin and subcutaneous tissues constrict, thereby minimizing loss of body heat through the surface, but inevitably allowing the anaemic tissues to cool still faster. The constricted vessels, as well as the cells they serve, may thus die—an ear or toe offered up to preserve the whole. Even in this case, it could be maintained that the organism enforces this action, since the vessels cramp down to their own destruction under whipping of nerve impulses from the autonomic nervous system. Similarly, with the paralysis and anaemia of the gut which accompanies strenuous muscular exertion—in an emergency requiring maximal effort, running for one's life—adrenaline is liberated by nerve action and this shunts blood and extra food reserves to the muscles. Even in the case of a leucocyte which, unlike its prototype the free-living amoeba, moves into rather than from a chemically injurious portion of its environment and is commonly killed while combatting infecting bacteria, there is really no question of voluntary altruism of the unit dying for the organism; for physical and chemical forces pull the cell about by its mechanical tropisms.

This raises the question of freedom and purpose. It follows from the already considered existence of reciprocal controls between the org and its units that environmental changes can act through the org to alter action of the unit, as well as the opposite. This maneuvering of units through the org, always so as to preserve the whole, carries the connotations of volition and of purpose—alike in animate and inanimate systems, in conscious and non-conscious ones. We do not know the nature of the mechanism which arranges bone cells along stress lines; or that which "chooses" one or another neuron to set off selective muscle action; or even that which directs a thrown ball into a parabolic trajectory, though in this simpler case we have named and quantified it. But certainly the mechanisms exist and the org acts upon its units, often regardless of their existence as discrete units.

Is there, then, any true freedom of action of unit or org not fully determined by org or unit and the outer world? I have neither the competence nor time to splash in this long running argument. But, whether or not a residue of free choice adheres to an org (and is multiplied in amount as the org increases in order; not by blind amplification of the

indeterminism of the unit but more nearly by an exactly opposite relation), its action is overwhelmingly determined at any moment by conditions external to it and those built by its history into its organization and so equally outside of its immediate control. In fact, "freedom" does not correctly imply the irresponsibility and absence of control so often attached to it. A "free" system, on the contrary, is one acting under the undisputed control of a single determiner or a group of allied ones; that is, running without conflict. A free falling body, a free sailing boat, a free swinging magnet, illustrate the point. "Free" orgs—including cells in the organism and organisms in the epiorganism—are ones responding with relatively little conflict to preponderantly allied forces, all tending to produce this kind rather than alternate kinds of activity. As Whitehead has said, "For effective freedom nature must be orderly. No condition is so servile as that of him who is subject to a capricious and incalculable tyrant."

Much could be added on the breakdown of org relationships in organisms, but a brief paragraph must conclude this portion of the essay. Malfunction of all types is recognized; and much disease is the result of partial breakdown of the integrating mechanisms. The usual anatomical or functional lesions—general edema from kidney disease, fainting from poor heart action, irritability from gastric ulcer and ulcer from a type of irritability—are familiar enough. But one form of org disintegration, the splitting from the whole of fairly independent portions, deserves comment.

The gradient along a flat-worm is low at the tail end and rather peters out when the animal is sufficiently long. The subordination of posterior by more anterior regions similarly weakens, and when this control is feeble enough the tail piece is essentially in the same org relation that it is when the front portions of the animal have been amputated. It then develops into a head and, finally, a complete small new organism still attached tandem fashion to the "parent" individual. Such a zooid, as it is called, eventually becomes torn away from the front portion and both lead normal existences; but before this happy solution occurs much conflict results from the independent behaviors of the tandem partners. Similar loss of unitary org control is involved as one factor in the formation of two-headed and other types of twinned monstrosities, in special embryo-forming tumors, or teratomas, and in the more familiar forms of cancer.

MUSICAL INHERITANCE

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THE whole problem of mental inheritance is in the air, both in the sense that it is current and in the sense that it is relatively intangible. The struggle is best illustrated in the current approaches to the problem of inheritance of intelligence. In this the geneticist has not gotten far from base, but much has been learned in regard to the nature of the issues involved. In the field of music the geneticist has approached the subject experimentally without understanding the musical life; and the musician has approached the matter practically without being a competent experimenter. The psychologist has certainly not done his duty in clarifying the issues. The most pressing need at the present time is for such clarification. This can not be the work of one man or one generation, but must be achieved through cooperation of both sides in order to clear the way for valid experimentation.

In order to indicate the character of the problem we are now facing, I shall first venture to state some fundamental assumptions upon which probably all competent investigators agree and, second, venture a little way in the direction of identifying concepts of musical life which can be dealt with experimentally.

ESSENTIAL PREMISES

The mechanism of heredity lies in a single germ cell carrying the character-determining chromosomes which consist of organized chains of genes. In the character and organization of these genes in the fertilized cell we find the complete "blue print" for the future individual in so far as it is to be determined by heredity. In the twenty-four pairs of chromosomes in the fertilized human germ cell we find the long and diversified heritage of each parent represented through the union of the sperm and the ovum. The selection and the organization of the genes in these chromosomes adequately represent what the future individual can be.

This genetic constitution is modified by the cytoplasm, the supporting part of the cell which is its first environment, and further by the entire embryonic environment. Any changes that take place after the launching of this cell, whether before or after birth, are regarded as environmental. In the embryonic life, this germinating cell develops by processes of cell division and specialization into the complete human organism ready to function more or less immediately after birth. This heritage has fabulous resources in the form of possible facilities for future development. As nature was prolific in the storing and transmission of countless hereditary characters in the genetic constitution, so the equipment of the child at birth is astonishingly prolific in the provision it makes for diversified development of the individual. Development from this stage on must, therefore, of necessity take place through a process of selection and specialization in which certain characters are given right of way and many are subordinated or inhibited by conflicting interests, but the great mass remain relatively latent or dormant. We may assume that superior musical talent is determined in large part by superior musical heredity, and that inferior musical talent or lack of talent may be determined in large part by a correspondingly defective heredity.

The science of heredity in the strictest sense focuses upon the study of the identification and organization of the genes in relation to the determination of characters which shall appear in the genetic constitution and determine future structures and functions of the individual. When the geneticist deals with specific anatomical structures, this relationship is traceable with comparative ease; but when he comes to deal with more or less complicated physiological or mental functions, the tracing of this relationship becomes rather baffling on account of the complexity of the final product.

Turning then to the issues involved in the interpretation of musical inheritance, we must face certain theoretical assumptions. One of them is that a scientific study of musical heredity can not be pursued on the assumption that mind and body are two distinct entities, each inherited independently. Nor can we hold the old doctrine of psychophysical parallelism. All human genetics proceeds on the assumption that the human individual is one psychophysical organism. Our musical experience, observation and measurement will therefore represent views from the mental side; our organic studies may be views of the same things from the physical side.

Furthermore, musicality is not one specific human trait but an infinite hierarchy of traits running through the entire gamut of the psychophysical musical organism. To make any progress whatever, the scientist must make the supreme sacrifice of attempting to deal only with specific isolable factors apparently small and remote in themselves. The situation is analogous to that of purely physical features. It is generally admitted that the structure of the physical organism is heritable. But when we show that the color of the eyes of the fruitfly is heritable and that this inheritance takes place in a very complicated way, as has been adequately shown, we have simply identified parts of the structure and function of the genes in one specific feature in the vastly complex physical organism, however fundamental and characteristic this particular feature may be. This analogy applies in principle to the genetic study of the musical life. The crux of the difficulty lies in the identification of heritable factors.

Again we must remember that the musical mind is first of all a normal mind, a normal psychophysical organism ready to begin to function immediately after birth. What we shall look for then in a psychophysical organism is the imminence of certain resources especially favorable or especially unfavorable to the normal functioning of the musical mind. We may assume that an average capacity present in the genetic constitution may be adequate for musical purposes but that exceptionally gifted persons require these traits in a correspondingly exceptional degree and that exceptionally unmusical individuals lack essential elements. The most wonderful thing is that a person can come into the world with a musical constitution at all, but the problem of heredity centers around individual differences, and these are more easily approachable than the total function. As in genetic studies of the inheritance of color-blindness it has been possible to identify types, so in musical hearing we may look forward to the identification of types of defect and types of superiority deviating markedly from the normal.

Common observation and reasoning convince us without question that musicality is inherited in some mysterious way and this follows also from general considerations of current theories of biological inheritance. But when it comes to the scientific determination of laws of such inheritance, we face high barriers. Biological laws of inheritance must be established in terms of the genes; a specific biological structure or function

must be related to gene organization. Let us call this measurement of the first order. Such measurements are most readily applied to anatomical structure and physiological function in the neuromuscular organism. This is notably clear in the anatomy and physiology of the ear and its connections. It is equally applicable to the anatomy and physiology of the vocal organs—the bellows, the vibrators and the resonators for voice. It is conceivable, for example, that the length, the mass, the mode of attachment, and the general position and shape of the vocal cords and the mounting of the voice box are heritable characters traceable to genes and referable to musicality as the physical organs for voice.

We can also find relationships to the endocrines, which are in large part the determinants of musical emotionality. Electro-physiology is now giving great promise for the identification of functions in the ear, the brain and its central connections and is establishing interrelationships. Many of the laws of heredity established by measurements of this order probably refer to fundamental biological principles of inheritance in the psychophysical organism as a whole. By a physiological analysis of the sensory, motor and central factors which operate most significantly in music, the systematist can set up a respectable body of biological facts in regard to musical inheritance which are antecedently probable in terms of the functions of genes and result in the structure and function of the musical organism.

Since the medium of music is sound, we shall look first for an exceptionally responsive or unresponsive ear, including not only the physical ear but the central organs in the nervous system through which it functions. This is basic for two reasons: first, because it determines what stimulation from the world of sound shall enter into the experience of the musical individual to a high degree; and second, because the purely physiological receptivity or organic response to sound acts upon and modifies the state of well-being or ill-being according as the auditory impression is beneficent or noxious in so far as its acts upon our circulation, metabolism, temperature and other organic processes. Such well-being or ill-being is, of course, in part the foundation for the feeling of musical pleasures and pains.

If we would gain a true and comprehensive insight into the nature and extent of role of environment in musical life, we must start with some established facts or reasonable assumptions of what is "given" for environment to act upon. The heritage is the capital fund which the environment invests or squanders. Only by knowing the hereditary contributions can we appraise the environmental contributions. In the study of the fruitfly, for example, the revelations of factors which must be regarded as environmental are quite as significant and essential as the revelations about the original organization of genes. The determination of the limits of heredity is the best means for revealing the functions and possibilities of environment. The music geneticist will therefore learn fully as much about environmental influences as he will about hereditary influences in studying heredity.

Psychophysical Measurements

The music geneticist can approach many significant aspects of the subject through psychophysical experiments for which we now have fairly standardized procedures. For the present purpose, we may call this measurement of the second order as compared with the anatomical and physiological measurements. It proceeds out of, and is a complement to, the anatomical and physiological foundations and probably represents the most fundamental approach from the psychological and musical points of view. These mea-

surements deal primarily with sensitivity and discrimination on the sensory side and the corresponding processes on the motor side. Among them we may recognize two levels: the simple or elemental, in which a specific mental process is related to a relatively specific organic basis; and the complex, which relates to cooperative functions of the elemental capacities. Of the former we have four, namely, the sense of pitch, the sense of loudness, the sense of time and the sense of timbre—each of which is correlated with a specific attribute of the sound wave, which is the musical medium. We have basic measurements of the hearing of rhythm, consonance, volume and sonance—all of which represent relatively complex patterns. Each of these complex functions has a unitary character. Rhythm, for example, is not merely time plus intensity; it possesses a unitary character. Because of the difficulty of dealing with the complex patterns, precedence should be given to the four elemental or basic capacities. Excellence in these capacities contributes toward ear-mindedness, of which the auditory image is the most specific characteristic; but at the present time we have no adequate objective method for the measuring of auditory imagery.

On the motor side we have corresponding measurements of speed and accuracy in the motor control of each of these factors represented in the sound wave, namely, frequency, amplitude, duration and form.

The term elemental should be used with caution because we never encounter a purely elemental state or process. Even in the very simplest form they are merely more or less specific phases of the mental organism; and at any level at which they are observable they probably involve environmental accretions. It is the old story: we never experience pure sensation but meaningful perception. Yet under the most careful experimental control the identification of such specific functions may be reasonably reliable and have considerable validity.

Adequate measurements of the sense of timbre are new and therefore have not been employed extensively up to date. But the sense of pitch, the sense of time and the sense of loudness, together with the sense of rhythm and immediate tonal memory, have been used extensively.

The significance of such measurements depends upon the rigidity of the scientific technique and the selection of subjects for experiment. Reliable measurements have been made on a variety of groups and for different purposes more or less related to the problem of inheritance. Studies have been made upon musically precocious children to determine to what degree they were gifted in each of these capacities. All the available blood relatives of six of the foremost musical families in America and a number of such families in European countries have been investigated. These capacities have been measured in selected virtuosi in various fields of music. The measurements have been used for the determination of qualifications for musical organizations and for the analysis of admissions to music schools. Simplified forms of the measurements have been made upon very young children in musical families. Numerous cases of failure in musical education have been investigated and often explained on the basis of presence or absence of these basic capacities. Surveys have been made on groups representing highly privileged or under-privileged children in the matter of musical facilities. Some of these measures are now a part of the standard tests and measures administered in the public schools so that comparisons can be made with blood relatives, and data are becoming cumulative for scientific comparison of successive generations. Numerous racial studies have been made on a large scale comparing these capacities, for example, in dif-

ferent degrees of race mixture—as in the transition from pure blacks through mulattoes to whites in a large Negro community, or the comparison of racial groups in Hawaii, the school children in different European countries, the comparison of Indians with whites, and the comparison of distinctive races and primitive peoples in different parts of the world.

From this large array of facts certain findings seem to be significant, taking these measurements as a group. First, the sense of pitch, the sense of loudness and the sense of time reveal no distinctly significant differences in racial groups, in culture-levels, or at age-levels, when adequately measured. In many cases this holds also for the sense of rhythm and tonal memory. This is probably indicative of the fact that the basic capacities for hearing in individuals now living and capable of being tested adequately are physiologically at the same level. This conclusion is in harmony with the observation that these capacities which function in music, function also in the vast varieties of orientation through sound at all levels of man now living. It is also analogous to what has been found in vision. Second, it develops that in each and every one of the groups studied there are enormous individual differences in each of these capacities and that the extent and distribution of these differences do not differ significantly from what we find in the public-school children of the United States. Third, where comparisons of capacity and achievement have been made reliably, it has been found that those who have achieved distinction in music have these capacities in a significantly corresponding degree; but much larger numbers of those possessing superior capacity who have not been discovered as musical either by themselves or in their environment are revealed. This fact rules out many of the statistical studies of heredity in terms of musical achievement. Fourth, these capacities represent relatively independent factors in hearing. Fifth, marked superiority or inferiority in these capacities is of predictive value for musical achievement and guidance in education.

On the motor side but little progress has been made. Principally because the measurements are laborious, significant elements have not been identified, and moderate motor capacities in speed and action are adequate for most musical achievements. Daily observations reveal that children may be slow and accurate, slow and erratic, fast and accurate, or fast and erratic in various degrees and combinations. It would, however, be of musical significance to discover to what extent and in what manner these traits are inherited from generation to generation.

In view of these discoveries, it is evident that there is some material available for technically rigid genetic interpretation in terms of currently recognized principles of inheritance. All the records on the six foremost musical families of America are available in the confidential files of the Carnegie Institution at Cold Spring Harbor. Highly reliable measurements on all the students in the Eastman School of Music for the last fifteen years are available. Various public schools have vast cumulative data, and elaborate collections are being worked upon in the Winderen Laboratory at Oslo. But with the exception of the Carnegie Institution and the Oslo collections, adequate measurements of whole families are absent.

What is needed now is a thoroughly reliable series of measurements on entire musical families and the interpretation of these by a thoroughly competent geneticist in terms of established biological principles of inheritance. It is especially important that both parties shall be competent to take into account the numerous

lessons which we have learned from the extensive efforts that have been made in the attempt to measure the inheritance of any mental trait, such as human intelligence. In the human situation we can not breed successive generations rapidly as in flies or mice for experimental purposes. We must, therefore, economize time and effort by taking the most readily available material. For this purpose I have suggested three possible methods ("Psychology of Music," McGraw-Hill, 1938). The first is that we start with the highest 10 per cent. and the lowest 10 per cent. in an adequate sampling of fifth-grade children in a school system and work back by making the same measurements on the available blood relatives of these two groups. In effective organization much time can be saved by making group measurements in a cooperating community, such as a city ward. A second procedure would be to secure an adequate sampling of musicians and measure forward and backward to cover three generations in which the matings of musical and unmusical parents could be traced. A third procedure would be a systematic collection of measurements on school children for a generation or more giving special attention to the showing of blood relatives. We can not, however, stress too strongly the importance of having these measurements made throughout by an experimenter thoroughly competent in this field and the equally thorough biological treatment of data by scientists thoroughly competent in that specific field. If a biologist wants to start the ball rolling from his point of view, the records in the Carnegie Institution furnish a fair and reliable sampling.

In proposing this conservative approach through psycho-physical measurements, I do not wish to belittle the insight, common knowledge and theories of inheritance which have been obtained by observation and statistics in terms of musicality as a whole—as in biography, autobiography and letters of great musicians or in the study of musical families. But we are confronted with the fact that these deal largely with unanalyzed situations so completely covered by factors of environment and training as to make them useless for strictly scientific purposes. Nor would I belittle the significance of general traits, such as musical intelligence, creative imagination and the artistic temperament, or facilities for specific skills, such as sight reading and the memorizing of repertoires. We know a great deal about these and unquestionably have the right to assume that they have an hereditary basis. But scientific studies in heredity may be more properly approached through the simpler and more elementary capacities.

For scientific purposes, we can not, of course, mix basic measurements and current ratings of musical achievement. There have been numerous approaches to this subject from the musical achievement point of view, and these have furnished many suggestive leads and probably point to unquestioned facts about the inheritance of musical talent. But the science of genetics rightly rests upon and demands the isolation of specific factors which can be measured; and for that purpose the musical geneticist must, for the present, sacrifice many otherwise interesting approaches from the point of view of rated achievement and be willing to await the laying of foundations of rigidly conducted measurements which can be described, interpreted and verified.

THE "CHAIR" FOR INSECTS?

By Dr. ROBERT CUSHMAN MURPHY
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A Pitfall in Eden

On a warm and peaceful evening I recently gathered new evidence of man's unique predilection for slaughter for its own sake. I was sitting alone on a flagged terrace that was sheltered on two sides by glass and on a third by the clapboards of an ancient and stately Connecticut home. The fourth side opened on the bland night air and on velvet shadows of box and great beech and tulip trees, while a familiar garden close, bowling green and fountain showed dimly under the sky reflection, with a backdrop of inky woodland beyond.

The floor and table lamps had not been turned on, but a light suspended above my singularly comfortable chair made the enclosure glow pleasantly against the dark, and illumined a thousand specks that were beetles, moths, leafhoppers, lace-winged flies and other small companions resting on the ceiling and painted woodwork. It was August, the Indians' "moon of insects," a fact confirmed by the rattle of tree-crickets and a mingled orchestration from hedge and garden that combined with the faint stir of leaves and other sounds too elemental to be discriminated without an effort to create the ambiance of a summer night.

In the midst of such contentment, however, there was one false note. At intervals of seconds a slight crackling, quite unlike the so-called "voice" of any insect, rent the air with an incisiveness out of all proportion to its volume. At first vague and puzzling, it presently centered my attention on the lamp itself, which became white and dazzling when the eye was lifted to its level.

The light proved to be fulfilling the purpose of a lure and deathtrap. Cylindrical in shape, its gleam in all directions passed between the bars of an electrified metal grid. Flying insects, even if as minute and filmy as mayflies, closed a circuit upon coming into contact with the bars. The crackling noise was simultaneous with a tiny burst, or sometimes a prolonged flutter, of blue flame, after which a scorched being dropped soundlessly into the projecting catch-pan at the base of the lamp.

I went indoors, hunted up a cardboard box in which to store the cupful of dead or maimed insects for future reference, and then turned off the switch of the light, ending its hazard for the moment.

The Voice of the Salesman

It took but a few days to become versed in the many cheerful possibilities of electrocuting insects, of which I had hitherto had no realization. After perusing the manufacturers' unprejudiced assurances, it seemed almost obvious that live-wire control was at the point of conferring inestimable benefits upon mankind in the way of increased comfort—not to mention the boon to agriculture.

"What! No mosquitoes? Exactly!," read one illustrated account. "This device, scientifically designed, combining attractiveness with effectiveness, utilizes illumination to entice insects to destruction. It annihilates flying pests instantly, providing absolute insect-free contentment to outdoor-loving people. Summer evenings offer the most wholesome opportunities. Our lamps are for the control of pestiferous and harmful

insects that fly in the dark. They eliminate the destructive worms bred by night-prowling pests, by killing the adult egg-layers."

"It is all very well," sang the author of another disinterested paean, "to speak of the enchantment of gardens lighted at night, of the peace to be found at twilight in a comfortable chair on lawn or terrace, of supper out under the stars; but how can all this be enjoyed when mosquitoes and gnats and moths buzz and sting and fly? The gardener and his guests can but flee to the screened house, leaving the fragrant garden to the insects. At least that is what they have had to do for years past. But today one can purchase a simple electrical device that, though harmless to humans, is death to bugs, and enjoy the garden at nightfall in comfort, while mosquitoes and bugs literally 'get the chair.'"

Not stopping at products that combine the ordinary domestic purpose of a lamp with a lethal function, the makers also advertised, among their many types covering a wide price-range, a mercury bulb trap for use "wherever bright illumination is not desired; the light source emits those parts of the spectrum that are attractive to insects." This can apparently be relied upon to get them anywhere, during daylight hours as well as in darkness. It may be hooked up at the far end of the garden, or out in the forest, for that matter. If the mountain will not come to Mahomet, Mahomet must go to the mountain. Still another lamp is recommended for situations where insects "are not prevalent in great abundance." It is important, it seems, to catch the stragglers and thus be on the safe side. High praise, in fact, is accorded a "portable bug-killer," which should be in all travelers' luggage and which is credited with a virtue of "luring every flying insect in a room at night."

The Testimony of the Condemned

By the time I came to the point of analyzing the catch from the first electric live-broiler of my acquaintance, I had gathered several additional cargoes of insect corpses, similarly finished off during the same summer season. It began to appear that these admirable lamps had earned for themselves a wide vogue.

Let us now sort and name the spoils, concealing nothing, adding nothing, and remembering, of course, that the samples represent but one general locality in Connecticut and only the month of August. And, lest any reader should rightly question my personal competence to identify and comment upon a varied assortment from the largest class of living organisms on earth, let me say that I have been at pains to submit all the specimens to professional entomologists whose reputations and authority are recognized by men of science everywhere.

The vast majority of insects have no common names, and to list the victims from three distinct catches by their respective Latin generic and specific names would result, from the layman's point of view, in wholly impractical jargon. Let us, rather, refer to them with the least possible degree of technicality, which will inevitably be bad enough. And let us follow the summaries of their kinds and numbers with notes upon their relation to nature and man, and, when called for, a further qualification based upon the somewhat contingent and artificial terms "beneficial," "neutral" and "injurious."

Plecoptera

Stone-flies, or salmon-flies. One example of these water-breeding insects, the larvae of which live in swift streams and furnish food for trout. Beneficial.

Homoptera

Frog-hoppers, or spittle-bugs, the larvae of which make the curious masses of foamy froth

in the grass. Four examples of one species. Food, chiefly weeds. Beneficial or neutral.

Leaf-hoppers. Sixty-two examples of seven or more species. Various members of this family are under certain circumstances to be regarded as pests, but the bulk of them are normal elements in the life of the woods, thickets and pastures. Even lawns have an abundance of leaf-hoppers, to which no horticulturist need pay attention. Neutral, or at most only slightly injurious.

Neuroptera

Lace-winged flies, aphis-lions or golden-eyes (*Chrysopa*). About 40 examples, representing one or more species of an exquisitely beautiful four-winged insect which one entomologist has described as "fit only to go on an Easter card, so pale and esthetic are her light-green wings." The food habits are almost uniquely important to man, for in both the adult and larval stages the golden-eyes eat nothing but plant-lice and scale insects. Neither the gardener nor the farmer has a better friend.

Lepidoptera

Sphinx moths. One small example, too burnt for identification. Although minus its wings, it was discovered to be alive at least twenty-four hours after electrocution. The feeding habits of the Sphingids are various, but the adults are flower-pollinators and the group as a whole is probably more beneficent than harmful.

Arctiid moth (adult of one of the woolly-bear caterpillars). One example of a species that lives chiefly on such weeds as plantain. Beneficial.

Noctuid moths. One example each of three species, the first a harmless feeder on such flower heads as wild asters, the second occasionally destructive to beans and other leguminous plants, the third a true pest because its caterpillar is one of the cut-worms. Neutral and injurious.

Geometrid moths. One example of a small leaf-feeder, the adult of an inch-worm. Generally regarded as injurious, although most of the large number of species are normal inhabitants of trees and lesser plants, attaining economic importance only in peak years of their population cycles. Because they furnish food to many predacious animals, including other insects and birds, they also form a large part of the "pasture" of nature.

Pyralid moths. Twenty-one examples of several species, mostly of the genus *Crambus*. This large family includes sundry pests, such as the introduced European corn-borer, which, however, was not found in our catch. The native species become troublesome chiefly when, because of the absence of some natural control, they break out in unduly large swarms. The caterpillars of *Crambus* are the familiar sod webworms, which cause neither farmers nor gardeners any serious concern. Furthermore, they constitute a source of food for ground-feeding birds such as meadowlarks, particularly for the nestlings. Neutral.

Tortricid moths. Fourteen examples of various species and sub-families. The introduced codling moth or apple-worm does not appear among the victims, which feed, respectively, on grapes, birches, sassafras, pitcher plants, goldenrod, certain garden shrubs and other vegetation. All or most of the catch must be regarded, from man's point of view, as no worse than neutral.

Gelechiid moth. One example of the genus *Recurvaria*, a minor pest on evergreens and ornamental shrubs. Injurious.

Diptera

Chironomid midges. Five examples representing one or more kinds of these harmless insects which compose the swarms that dance in air, the mass as a whole remaining in one position. Neutral.

Ceratopogonid flies. Two examples of a biting midge. Since these are annoying, we may call them injurious.

Crane-flies. One example of the genus *Anisopus*, which breeds and feeds in wet and decaying vegetation. Neutral.

Gall-midges. Twenty examples representing several forms of the family Cecidomyiidae, a group that includes the notoriously destructive Hessian fly. This objectionable species, however, does not appear in the catch, which is made up of native gall makers on various weeds and other plants and of one or more kinds that fulfil the desirable function of devouring plant-lice. Injurious and beneficial.

Dolichopid flies. One long-headed fly of the genus *Neurigona*, which captures and eats midges and other small soft-bodied insects and their relatives. Neutral or beneficial.

Blow-flies. Two examples of green-bottles or Sarcophagids, which are well-known disposers of carrion and therefore beneficial. They are chiefly diurnal insects and their presence in the light-trap may be accidental.

Tachinid flies. Seven of these economically important insects, not in sufficiently good condition to be identified as to species. They are parasitic upon caterpillars, grasshoppers and other insects, depositing the eggs or larvae upon the skin or within the body of the host. Beneficial.

Anthomyiid flies. Eleven examples of the

leaf-miners, genus *Pegomya*, one example of which is the generally injurious corn-maggot fly. Of the other species one sometimes infests beets, another ivy, but most of them attack burdock and other weeds. One additional closely related fly among the victims is a scavenger on decaying vegetation. Injurious and neutral.

Sciarid flies. Two or three examples of a fungus-gnat, which breeds in toadstools and other fungi. Neutral.

Coleoptera

Ground beetles (Carabids). Five examples representing five different species. All are man's co-workers, because these beetles feed upon soft-bodied plant-eaters, of which caterpillars comprise the bulk. Beneficial.

Hydrophilid beetles. One example of a land-living relative of the true water-scavengers. It feeds upon fly larvae in dung and decaying vegetation. Neutral.

Rove beetles. Three different small representatives of this family, the Staphylinids. They live in decaying organic matter, preying in part on other insects. Beneficial or neutral.

Click beetles. Two examples of an Elaterid, the larvae of this particular form being root-borers on woody plants. Possibly injurious.

Scarab beetles. Two examples representing two species of the genus *Aphodius*. These are dung-beetles of generally harmless habits. Neutral.

Chrysomelid beetles. Three examples representing three species of small leaf-eaters. Perhaps to be classed as injurious, though nothing to worry about.

Hymenoptera

Ichneumon wasps and other parasitic insects of this group. Seventeen examples of several kinds, not identified as to particular species. All of them are of great importance because their larval stages feed upon and destroy caterpillars, wood-borers and other insects which man also has to combat. Beneficial.

Ants. Five examples of two or more species of winged ants. They are to be regarded as beneficial because of their value in reworking the soil, which in some districts exceeds that of earthworms.

Who Flies to the Light?

The roll of victims, in conjunction with the explanatory remarks demanded by simple justice, tells its own story. There is probably not one serious enemy of man in the entire sample. "Pestiferous insects"—by any other criterion than that of outmoded squeamishness—are conspicuously scarce. Especially noteworthy is the absence of a single mosquito, although our little morgue contains the bodies of a number of non-biting Chironomid midges that are often mistaken for mosquitos.

"Most bugs, moths and insects," writes one sponsor of the electric method who plays fast and loose with zoological terms as well as with the truth, "are attracted by light, so with any one of these electrocutors night life (the garden variety) becomes much more enjoyable. Even to the music lover the song of Mrs. Anopheles is never welcome. To prove to this mosquito that she is an undesirable companion, there is one efficient way—electrocute her."

What this writer means to say would be interesting if we could rely upon it, but it is up to the lamp manufacturers first to show us evidence of mosquitoes decoyed against their live wires. It so happens that while mosquitoes have been experimentally attracted by electrically controlled vibrations that reproduce the hum or muscial note of their whirring wings, and while they respond to some extent to warm surfaces, the readiness with which they react to various types of illumination, including the "New Jersey light trap," is still a moot point. Furthermore, Wats and Bilderbeck, experimenting in India, report that "8,000 other insects, mostly beneficial," were caught during ten hours' use of an "Entoray" machine along with only 19 examples of anopheline mosquitoes! Neither is it a fact, as stated by the writer of the foregoing quoted paragraph, that "most insects" exhibit the reaction called "positive phototaxis," although an unfortunately large proportion of *useful* kinds appear to do so.

The moth that flutters into the flame

of the candle is both an ethnic tradition and an everyday observation, and the story is usually cited to point a moral. The strange response is not due, however, to an idle curiosity that leads the creature to "play with fire," nor is the infatuation determined by its own volition. On the contrary, such suicidal behavior is purely automatic. The mechanism of phototaxis, which may be either negative or positive, is highly complicated, differing greatly among various groups of animals and even among closely related insects. Under the influence of a distant source of light, such as the moon, a photopositive moth can maintain a straight course. When, however, the light is close at hand, the angle of rays striking certain cells in the retinas of its eyes is constantly changing. The rays are converted into energy that affects its muscle-tone asymmetrically, and its movements follow what is called a logarithmic spiral which leads it ineluctably toward the source.

Now it is common knowledge among economic entomologists, who have long made use of various types of light-traps, that the bulk of the undeniable pests are not drawn to such lures. The Japanese beetle, to choose an example that everybody knows, remains quiet and beyond temptation after nightfall. More perverse still seems the fact that in certain large families of nocturnal insects the greater number of species are photopositive, but many of those particularly inimical to man's interest are not! That this is somewhat damaging to claims for the annihilation of "destructive worms," as put forth by the electrocutioners, will doubtless not alter their sales tactics.

In the opposite balance of the scale we have seen evidence that the light-susceptible insects, which succumb to the treacherous lamps, include many such indispensable forms as devourers of plant-lice, parasites of plant-eaters and pollinators of blossoms. Furthermore, those aquatic insects that at one period or another of their life histories furnish the natural food of fish are highly photopositive, and incalculable numbers of them have already perished on electric grids.

Ignorance plus unscrupulous advertising, coupled with the prevalence of many night-flying insects (sometimes including mosquitoes) along waterways, has led to a ready sale of the diabolical lamps to owners of cottages on the banks. One of the foremost advantages of homes so situated lies in the opportunity for fresh-water fishing. It is ironic, to say the least, that contraptions on the porches of countless such residences throughout the vacation season are nightly luring to destruction a host of caddis-flies, fish-flies, stone-flies, Dobson-flies and mayflies, the immature stages of which furnish an irreplaceable prey for trout and other fish. Such insects do no harm whatsoever. The Dobson-fly, for instance, is the parent of the odd, water-living hellgrammite, crawler, hell-devil or conniption-bug, which spends two or three years under stones in the stream bed before emerging as a flying adult, and which, as every country boy and ardent angler knows, makes an irresistible bait for bass.

Insects as Friends and Foes

A distinguished American entomologist once made the modest statement, "In the large economy of nature insects are beneficial." Most authorities would put the case more emphatically, because it is certain that higher forms of life, man included, could not survive on this planet without them. It is unnecessary to recount the manifold reasons, but, for example, our textiles depend upon insects —silk because an insect is the manufacturer, cotton and linen because of direct fertilization of the plants, wool because

insect-pollinated clover is necessary for the rearing of sheep. Even though insects inflict damage upon orchards, there would be no orchards without insects to crosspollinate the blossoms. From the standpoint of such a restricted group of agriculturalists as fruit-growers, who may be the heaviest sufferers, it has been estimated that the insect population is at least 80 per cent. useful. Of about 600,000 species of insects known to science, perhaps not more than 200 can fairly be called enemies of man. Not more than one half of one per cent. of all the kinds in the United States are seriously injurious.

What constitutes a "pest"? One answer would be that it is any species, whether of generally good, bad or indifferent habits, that gets out of bounds and actually disfigures the face of nature or devours substantial proportions of man's goods. Such infestations formerly resulted chiefly from normal population-rhythms over regular periods of years; they could at least be relied upon to pass quickly. Nowadays, in well-settled regions, they are often a product of man's interference with the natural controls; his own short-sightedness deserves the blame, a fact aggravated by the likelihood that his next step may go only further to make the attempted cure worse than the disease. The real cure lies in not forgetting the place of enemies that have been preying upon the despoilers for millions of years.

A second definition of a pest is an insect that does not belong where it is found. The Hessian fly, which has been called the most destructive insect in America, apparently came to Long Island with the regiments of Hessian mercenaries during the Revolution. The gypsy moth, San José scale and other undesirable aliens reached us at later dates, and have flourished at our expense because they have given the slip to enemies that keep them in check in their native homes. One of the remarkable characteristics of most insects is the high degree of specificity in their feeding habits; many of them depend for their very existence upon some other single kind of organism, plant or animal. When chestnut trees died out along the eastern seaboard of the United States, the chestnut weevil likewise disappeared; when the Japanese beetle reached this continent without its native Asiatic parasites, it waxed unduly strong. The logical way to fight insects is to enlist the services of other insects that eat them, importing the predacious species when necessary.

In recent years a very wide attempt has been made to find methods of artificial control, some of which have been useful, though most of them prove too non-selective when they are applied "in the open." Even electrocuting traps might be of wholly appropriate application under special circumstances, such as in granaries, tobacco warehouses, etc., nor is there any reason why electrified screens should not become important in the elimination of houseflies around stables. The observed results of killing by the lamps, however, make them indefensible for general use on porches and in gardens. Dr. Frank E. Lutz, of the American Museum, once aptly referred to indiscriminate processes for destroying insects as equivalent to "releasing poison gas in a crowded restaurant to kill a hold-up man."

The cautious and responsible attitude of a manufacturer interested in something beyond the mere sale of his product is expressed in the following letter from an officer of an electric company to an entomologist, written in February, 1935:

> We have been approached a number of times with the problem of devising insect traps to be baited with blue and ultra-violet lamps of our manufacture. We have hesitated so far because we were not entirely sure of the economic

soundness of such wholesale killing, believing that not only the undesirables might be killed, but also there might be a wholesale slaughter of the innocent.

To establish a basis of judgment of this economic entomological question, I am asking your advice as to the soundness of the use of the blue or ultra-violet light as a trap bait for methods of protecting some of our plant and tree growths. I hope that you will express yourself freely for I am concerned solely with the fundamental truth in this problem.

What naturalists, as well as the public, need to know is more about the management of insects by purely biological, rather than chemical or mechanical, means. There is also undoubtedly room for research into the great question of new ways in which insects can be made to serve man. The silkworm moth and the honey-bee have long been put to a domestic purpose; operators of aquaria and aviaries breed great numbers of the beetle larvae known as meal-worms, as well as certain other insects, to furnish animal forage. Relatively little thought, however, has ever been given to the opportunity for making some incidental use of wild insects as a by-product of their economic control. Yet I recall one elderly duck farmer on Long Island who practiced an excellent example of this possibility. During the mating season he used to imprison numbers of gigantic female Cecropia and Polyphemus moths in cages of wire screen that stood on the ground in his duck pens. The scent of the females, carried far down the wind, would cause a constant procession of male moths to fly up and beat eagerly against the screen. This also kept a mob of ducks pressing about the cages, snapping at the unfortunate male moths and fattening on their oily bodies. Not quite sporting, you may remark, but at least this method of control was reasonable and purposeful. It was not sheer waste.

The Rift in the Lute

The frequently misunderstood term "balance of nature" refers to a product of trial and error throughout an unimaginably long period of evolution that began ages before man or any of his recognizable ancestors appeared on earth. The climax ultimately attained in the interrelations of climate, soil, plants and animals represents the balance. It is not a fixed state, because balance implies a dynamic movability, but it is a fit and desirable condition which endures just so long as no new and abrupt factors enter the field to create an imbalance. Man, of course, has been and is now the chief "upsetter." Part of what he has done has been necessary and more of it hardly avoidable. But the belief that "hunches" and slap-dash conclusions arrived at without any fair tests can improve matters that have gone wrong is the most pervasive error in the minds of human beings to-day.

Kill, kill, kill, is the slogan, if there is anything in nature to complain about. Kill, not for sustenance, nor even for decent sport. I have before me, for instance, a report on one of the thousands of popularly organized "Varmint Killing Contests" that take place each year in our country. This particular one refers to a county in West Virginia. Twenty-seven different tradesmen, shops, hotels and the mis-named Conservation Commission of the state offer cash prizes for the highest individual slaughter during a shooting term of several months, and the listed "varmints" include foxes, hawks and owls (meaning all kinds, some of which are exclusively beneficial), kingfishers, chipmunks, turtles, water snakes (which rank 500 points), "all other non-venomous snakes" (100 points), and mud-puppies or river salamanders.

Many a person whose gorge would rise at the idea of deliberately encouraging the destruction of chipmunks and owls would still be incapable of becom-

ing excited over the senseless wiping out of insects. This is because the really desperate battle between man and certain introduced insect pests has been lopsidedly advertised; the association of the name "insect" with something essentially objectionable has become all too deeply ingrained. Yet there are scholars to-day who predict that conservational struggles of the not distant future may involve large-scale campaigns for the protection, rearing and transplantation of enough insects to enable man to provide for his own survival! The idea has been developed with the sardonic touch of a modern Dean Swift, yet with a weight of conviction that is not at all funny, by Dr. Edith M. Patch, formerly state entomologist of Maine.

The instinct of self-preservation makes the best of us callous about the fate of other organisms as long as we can feel that the cause being served is a righteous one. It is therefore hardly reprehensible that the average reader or card-player, sitting luxuriously in the soft glow of an electrified lamp, can listen to the sizzle of each victim as it strikes the grid with a sort of subconscious contentment in which he would be loath to acknowledge any tinge of sadism. Perhaps it is akin to the exultation of the old frontiersmen whenever "another redskin bit the dust." The manufacturers of the lamps are quite willing to take advantage of this specious attitude toward insects, and they would regret wide dissemination of the knowledge that vastly more beneficial than harmful kinds are likely to be slain every time the switch is turned on. The one disinterested fact to be emphasized, however, is that the lamps are made primarily to *sell*, rather than for either the good or evil they may subsequently accomplish.

MIND IS MINDING—BUT OR STILL?

BUT!

PROFESSOR LESLIE A. WHITE, in the February (1939) number of THE SCIENTIFIC MONTHLY, has attempted to convince the philosophical world that the so-called "mind-body problem," which has been a chief concern of the greatest thinkers since time began, may be shown to be no problem at all by the simple device of substituting the participial form "minding" for the more familiar substantive, "mind." This is as bold a step on the part of a scientific anthropologist as would be the endeavor of a philosopher to prove by some linguistic legerdemain that the problem of the origin of the human species has no meaning.

As a matter of fact, Professor White's suggestion is at least as old as Aristotle, and his analogy that "mind is to body as cutting is to a knife" was actually used by the Stagirite himself. And to-day the world is full of psychologists and philosophers who have been saying practically the same thing for years. These facts do not make the theory true, however, and all who try to explain away the mind-body problem in this cavalier fashion overlook some important considerations.

There are two distinct parts to Professor White's thesis, between which, however, he fails to discriminate; and yet only confusion can result from such a failure. We need not quarrel with the assertion of his title that "mind is minding," an activity rather than a thing; but when he goes on to identify "minding" with behavior ("Mind is minding, or behavior")—with reaction to environment—we must demur. It is perfectly allowable either to consider "minding" a *variety* of behavior, or to restrict the term "behavior" to overt acts and treat "minding" as a quite different kind of activity, but it is simply fallacious to identify the two types.

Under "minding" are included such activities as thinking, remembering, feeling, desiring, etc.; for as mind is minding, so thought is thinking, memory is remembering (or a name for the capacity of remembering), etc. But such overt acts as walking, talking, climbing, approaching, retreating, etc., belong to an entirely different category from the former. Walking, indeed, is a "function of the body," and so are the other activities in the second list; but it is simply nonsense to speak of thinking, remembering or "minding" as "functions of the body," as do Professor White and others of his school. Both these sets of activities are functions of one *ego*, it is true—*I* think, *I* walk, *I* desire, *I* act—but they are two entirely different kinds of functions. For one of these sets the word "behavior" is especially appropriate, and for the other set some such word as "mentation" (or "minding," if one prefers); and the words "body" and "mind" respectively refer to that aspect or part of the *ego* which is especially concerned with the corresponding one of these two kinds of activity. Whether these should be described as "parts" *or* "aspects" of the self is precisely one of the points at issue between different theories of the mind-body relation; but no amount of verbal gymnastics can possibly eliminate the *problem* of that relationship.

JARED S. MOORE

STILL!

PROFESSOR MOORE'S criticism of my paper raises two points: (1) Are "mind" and "matter" two different kinds of reality, different entities, or is mind merely a property of matter in cellular (living) form? (2) What class of phenomena shall we label with the word "mind"?

(1) As indicated in my article, all scientific progress in biology and psychology has been made on the basis of the materialistic, mechanistic assumption that "life" and "mind" are merely

properties of matter-organized-in-cellular-form, just as iron or "iron-ness" is a property of one kind of organization of protons, electrons, etc., while "gold-ness" is the property of another kind of organization of the same sort of particles. How "matter"—carbon, iron, calcium, etc.—can come to have cellular form and manifest those properties which we call "life" and "mind" is, however, a real problem—to the solution of which "linguistic legerdermain" can not, of course, contribute anything. But neither can the philosopher. This is a task for the scientist—the physicist, the biochemist, the biologist.

(2) To what class of phenomena shall we attach the label "mind"?

The behavior of any living organism has two aspects: intra-organismal and extra-organismal, *i.e.*, processes whose locus is within the organism, and reactions between the organism and the environment. "Intra-" and "extra-" are merely aspects (not parts) of the integral process which is living. Thinking, remembering, desiring, etc., belong to the within-the-organism category; walking, climbing, etc., to the reaction-to-the-environment category. Now the question is, To which category shall we apply the word "mind"? Professor Moore wishes to restrict it to the within-the-organism category. I wish to restrict "mind" to the reaction-to-the-environment category —with one exception which will appear in a moment. All definitions are arbitrary. But some definitions are better than others, better in the sense that one tool is better than another for a given purpose. I believe that my definition is the more fruitful one for science.

We agree with Professor Moore when he declares that thinking and walking belong to "entirely different categories." We agree also that it would be "fallacious to identify the two." *But*, there is an important point which Professor Moore overlooks. Although logically distinct, "mind" and "(overt) behavior" are *biologically inseparable*. Furthermore, the *only way* in which the scientist can observe thinking, desiring, etc., in *all* the lower animals and in *all human beings except himself*, is *in terms of overt behavior*—such as "walking, talking, climbing." The limited and defective observation of *one single mind* (*i.e.*, one's own, through introspection) is not sufficient for the scientist. Thus, the scientific study of mind (thinking, desiring, etc.) *is and must be*—except for the meager and dubious contribution of introspection —the *study of the reactions of organisms to their respective environments.*

The scientist, like the philosopher, insists that his categories be logically valid. But mere logical validity is not enough; his categories must be useful, fruitful, as well. To insist, as Professor Moore does, upon keeping "mind" and "behavior" separate and apart is to render the study of mind sterile and to leave the phenomena of behavior unintelligible. It is precisely because the scientist freely employs the data of the one category to illuminate and render intelligible the other—in a sort of cross-fertilization process—that his labors become fruitful. Far from being "simply nonsense," the interpretation of mind as overt behavior has shown itself to be the most effective way of studying mind that we have at our disposal to-day. Also, it provides the most satisfactory way of disposing of—if not of "solving"—the mind-body problem.

To cherish the "mind-body problem" upon which the "greatest thinkers" have lavished their genius "since time began" without having brought the solution "any nearer now than then" may be dear to the hearts of some philosophers. But to-day, when science yields such abundant and much-needed returns for intelligent endeavor, it seems a waste of time to continue to wrestle with a problem that has defeated "the greatest thinkers" for ages. How long should a hen brood on a hard, roundish, white object before she concludes that it is not an egg but a door knob?

LESLIE A. WHITE

BOOKS ON SCIENCE FOR LAYMEN

CHILDREN'S SCIENCE BOOKS PUBLISHED IN 1939

THE year 1939 contributed meagerly to the literature of science for children. Its outstanding achievement, the revised edition of Anna Botsford Comstock's "Handbook of Nature Study" (Comstock, xx + 937 pp., $4.00) is intended to be used with youngsters rather than by them, unless they are of high-school age. This limitation also applies to "Thoreau, Reporter of the Universe," by Bertha Stevens (John Day, xiv + 229 pp., $2.50), although the book is advertised as a selection of Thoreau's writings for "all readers from eight to eighty." Though the selection has given this writer more pleasure than he ever derived from Thoreau's unabridged writings, it still seems beyond the capacities of children under thirteen or fourteen, unless they are guided by adults whose knowledge of nature exceeds their own.

"Seeing the Unseen," by Robert Disraeli (John Day, 158 pp., $2.50) is a revision of a book already widely used by children of ten to fifteen years. About half its space is devoted to photomicrographs of readily available subjects and half to descriptive text. The latter is readable and stimulating, even though it is strongly teleological in tone.

Another common fault appears in "Garden Creatures," by Eleanor King and Wellmer Pessels (Harpers, 64 pp., $1.25). This is a very simple, informative and admirably illustrated account of snails, earthworms, beetles, spiders and other creatures of the back yard or vacant lot. To the authors, the blister beetle that invades bees' nests is "wicked," and "can hardly be said to lead the life of an honest gentleman." But beetles are not gentlemen. If they lead lives that are proper to beetles, why should they be reproached?

The "Boy's Book of Insects," by E. W. Teale (Dutton, 237 pp., $2.00) is a straightforward "how to do it" book for youngsters who are old enough to collect, rear and study insects. It also contains necessary general information on anatomy, classification and habits of the main insect groups. Most of Mr. Teale's readers will be fourteen or older, as will those who use "Our Small Native Animals," by Robert Snedigar (Random House, 308 pp., $2.50). Mr. Snedigar tells how to care for frogs, turtles, snakes, mice and a variety of other vertebrates. His suggestions will help those who seriously want to keep captive animals, but may discourage persons who think that any odd cage or tank will do for a rabbit, a snake or a newt. That such persons should be discouraged goes without saying.

Turtles and frogs, in their free state, appear in "Let's Go Outdoors," by Harriet Huntington (Doubleday, Doran, 89 pp., $2.00), though most of this book is devoted to snails, insects and other invertebrates. Miss Huntington has successfully put biology—significant biology, not catchy trifles—into language that can be read by second-graders and read to any child of four. Her text is accompanied by the best photographs to be found in any science book for children, and the publisher has reproduced them in large size, by rotogravure. In all, "Let's Go Outdoors" is the discovery of 1939, so far as children's science books are concerned. It is pleasant to know that a companion volume on the seashore, with even better photographs, is ready for the press.

R. T. Peterson's "Junior Book of Birds" (Houghton Mifflin, xv + 92 pp., $2.00) is planned for readers nine to twelve years old, especially if they live in the eastern half of the United States.

Illustrations include twenty-four of the familiar Audubon Society color plates, as well as many sketches which illustrate bird attitudes and activities.

W. J. Wilwerding has continued his biographies of African mammals in "Tembo" (Macmillan, 138 pp., $2.00). Although he sets out to tell "all that is known" about the natural history of African elephants, Mr. Wilwerding devotes most of his book to elephant hunting and Tembo's marvelous escapes. Neither the writing nor the drawing ranks with the author-artist's earlier work, for awkward and stereotyped expressions abound and the pictures suggest stuffed elephants of the old-time museum.

In "The Chisel-tooth Tribe" (Harcourt, Brace, 200 pp., $2.00), Wilfrid S. Bronson presents a natural history of the rodents, with emphasis on habits, distribution and ecologic relationships. All this could be made stodgy, but Bronson's ability to write with humor as well as clarity and balance, plus his clever drawings, have resulted in a book that delights youngsters and adults to whom this reviewer has shown it. One hopes that it will be followed by similar volumes on other important animal groups.

Also clever, though not so successful, is "How Father Time Changes the Animals' Shapes," by Gaylord Johnson (Messner, 185 pp., $2.00). It describes the migration and evolution of vertebrates, but Father Time (a malnourished, Neanderthaloid old fellow) and a rolling pin that lengthens necks and legs are not fortunate devices. After all, giraffes are not cookies, nor was time, just as time, a causal factor in evolution.

As in previous years, the vast resources of archeology have been scarcely touched. "Turi of the Magic Fingers," by H. L. Williams (Viking, 172 pp., $1.75), is a routine boy's story of early Magdalenian man, with very crude illustrations. The real Turi, whether boy or man, obviously was a better artist than Mr. Williams, and knew more about the anatomy of animals.

Modern man, as well as astronomy, geology and much else, appear in "The Child's Story of Science," by Uncle Ray (Putnam, viii + 246 pp., $2.50). This is a collection of the well-known syndicated articles by R. C. Coffman, edited by scientists at the University of Wisconsin. Though necessarily brief, these articles are reliable and well written. So far as geology is concerned, they are vastly superior to "The Book of Stones," by J. F. Hausmann (Whitman, 33 pp., 50 cents). Here youngsters may learn that all stones come from mountains, that steel scratches quartz, that polyps are mouths, and that rocks were metamorphosed because they laid (*sic*) on ocean beds or under other layers of rock. Most amazing of all, this book and a series of others much like it are "sponsored and copyrighted" by the Board of Public Education, Philadelphia. Can this be science as it is taught in Philadelphia schools?

Still, it is not much worse than "America's Treasure," by W. M. Reed, edited by Carey Croneis, of the department of geology, University of Chicago. (Harcourt Brace, xviii + 395 pp., $3.00). Here the author of "The Earth for Sam" undertakes to explain the geology of our natural resources, but becomes hopelessly confused as to processes of sedimentation, uplift, intrusion, dynamic metamorphism and the origin of ore shoots. He also makes many errors in routine matters of geology and paleontology, on which reliable information is available in almost every college text-book. "America's Treasure" does no service to Mr. Reed's reputation as a writer of science for children and never should have been published.

Conservation, barely touched by Mr. Reed, appears in two other books. One

of these "Forestry and Lumbering," by Josephine Perry and Celeste Slauson (Longmans, Green, 125 pp., $1.50), is an admirably illustrated discussion of forestry in various parts of the United States, but is dully written, with nothing to rouse the imagination of children. In "Working with Nature" (Harpers, xv + 181 pp., $1.20), Eleanor King and Wellmer Pessels provide a foundation of nature information upon which they develop a simple outline of wildlife conservation. The method makes repeated contacts with the daily lives and observations of children, predisposing them to conservation before that subject is dealt with. As in all books by King and Pessels, illustrations are excellent and format is pleasing.

In conclusion, we may say that 1939 changed the established picture of science for children only by adding one new and very competent writer who addresses the four- to seven-year-olds. It filled none of the obvious gaps in the physical sciences; it produced nothing worth while in archeology; it contributed less in ethnology than did any other year since 1929. It also did nothing to fill the voids left when Seton and Charles G. D. Roberts stopped work. Youngsters who want what those men provided still must use cheap reprints of "Kindred of the Wild," "Rolf in the Woods" or "Two Little Savages."

CARROLL LANE FENTON

PHOTOGRAPHING THE INVISIBLE[1]

INFRARED photography owes most of its value to the differences in behavior of certain materials toward infrared and visible radiations. Many opaque objects are unexpectedly permeable to the infrared, atmospheric haze (but not fog!), human skin, a 6 mm layer of boxwood, sycamore or Siberian pine. The converse is not so true, and the transparent substance which is impermeable to the longer, invisible radiations is exceptional. A 1 cm layer of 10 per cent. aqueous copper sulfate is an example.

Practical applications of a vast quantity of empirical observations have been made, but as the author points out, only the fringe has been touched. The purpose of the present work is to survey the accomplishments, and to describe methods and their underlying principles for the guidance of the practical infrared photographer. Dr. Clark, who is on the staff of Kodak Research Laboratories, has made numerous contributions to the scientific literature. As an example of his lucid style, reference is made to "Seeing the Invisible," SCIENTIFIC MONTHLY, 41: 481, 1935.

As would be expected, progress has been made since the several-minute exposures by R. W. Wood in 1910. Due chiefly to the painstaking synthesis of whole classes of complex dyes, comparable photographs can now be made in 1/25 second. The author is thorough. He depicts the structural formulae of 17 of these sensitizing dyes, and gives the chemical synonyms of popular names, such as kryptocyanine and xenocyanine. He indicates, however, that even the most enthusiastic amateur will do well to purchase his plates and films already sensitized.

The photographer who is thinking of entering the field will be gratified to learn that no essentially new technique need be mastered. Virtually the same developers, stop baths and fixing solutions are used. Adequate formulae for all solutions are appended, and directions for sensitizing ordinary plates, calculated to be least likely to result in disappointment, are included. There are mathematical discussions of light and lenses, but these are not essential to a very fair understanding of the infrared method.

[1] *Photography by Infrared.* By Walter Clark, Ph.D., F.I.C., F.R.P.S. Illustrated. x + 397 pp. $5.00. John Wiley and Sons, Inc. 1939.

Some of the practical applications are: Examination of paintings for authenticity; examination of documents for alterations; deciphering of faded or partially burned papers; aid to medical diagnosis; investigation of the atmospheres of Mars, Venus and other planets; discovery of new stars; aerial photography.

In the case of paintings, the pigments are of course a complicating factor, but the applicability of the infrared method may be said to depend upon the following fact: The refractive index of a hardened linseed oil film increases with age; the effect of this is to increase the permeability of the paint film to infrared radiations.

One of the most striking of the illustrations consists of a paragraph in Latin (*a*) by visible light, and (*b*) by the infrared. In the former, 9 of the 13 lines are obliterated by the heavy black censorial ink; in the latter the original text is plainly legible. How long it will be before the censors start using a better ink is the pertinent question.

Another illustration is from a photograph of the Black Hills and surrounding terrain, taken from a balloon at 72,000 feet. The curvature of the earth is plainly discernible.

One field in which the infrared method will, presumably, always yield negative results is the realm of psychic research. The author states that he has frequently been asked to recommend infrared technique for investigating seances, but has never been informed of the outcome; "probably because . . . the results are not made public."

The text appears to be free from typographical errors. There is an exhaustive bibliography at the end of each of the sixteen chapters, and author and subject indexes at the end of the volume. The sole criticism is that the latter seems unnecessarily abbreviated.

THOMAS B. GRAVE

THE LIFE OF THE MIND[1]

THE history of Freudian psychoanalysis is the story of one of the most remarkable phenomena of the present century. When the basic concepts were enunciated by Freud in 1896 their author was reviled and even expelled from the Medical Society. Nothing daunted, he continued his clinical studies and his writing, and soon attracted followers. Tremendous resistance was widely manifested by those whose self-assurance was threatened by the revelation of the actual rôle of the emotions and of the instinctive life; the movement and its author were ridiculed and accused of obscenity and worse. In much the same way the ecclesiastical authorities raged at the teachings of Copernicus, but the truth made way irresistibly! To-day, despite the determined opposition of the past (and there still remain some doubters!), psychoanalysis has not only exerted a widespread influence upon anthropology, philosophy, sociology and education, but has revolutionized the outlook of psychiatry and has rendered valuable contributions to general medicine, even furnishing the basis for a new field of study, psychosomatic medicine. No psychiatrist, whatever his alleged "school" or whatever psychiatric language he may speak, studies his cases without utilizing at least some of the concepts discovered and elaborated by Freud.

Dr. Hendrick, the author, is a highly competent psychoanalytic psychiatrist, an able student of the field and a writer of great clarity. The present volume is the second edition, revised and enlarged, of a work which first appeared in 1934. So rapid have been the advances of psychoanalysis in the past five years that two new chapters have been added, one on the psychological study of organic disease and one on the extra-medical applications of psychoanalysis.

[1] *Facts and Theories of Psychoanalysis.* By Ives Hendrick, M.D. Pp. 369 + xv. $3.00. Alfred A. Knopf. 1939.

The book is divided into four parts, namely, "The Facts of Psychoanalysis," "The Theories of Psychoanalysis," "Therapy by Psychoanalysis," and "The Psychoanalytic Movement." There are also suggestions for further reading, a glossary and an excellent index.

The author does not fall into the trap of oversimplification, as many less well-versed writers on the subject have done; on the other hand, he does not encumber the book with adventitious material. He deals with the essentials, fully and clearly. He is frankly convinced of the value of psychoanalysis and the soundness of its tenets; otherwise, of course, he would not and could not have written such a work. Nevertheless, he recognizes that certain principles are theoretical, hypotheses based upon observed clinical data but not perhaps in themselves capable of scientific proof. He attempts, in short, to preserve a scientific point of view in his discussion; that this adds much to the value of the book goes without saying.

Dr. Hendrick has rendered a valuable service to those who are interested in the life of the mind, who recognize that Freud let a flood of light into places hitherto *very* dark and who desire authoritative and readily available information upon Freud's discoveries and methods. The book is sound, well-organized, convenient and very readable. It is heartily recommended to the readers of THE SCIENTIFIC MONTHLY.

WINFRED OVERHOLSER, M.D.

THE RISE OF CIVILIZATION[1]

OUT of the riches of his knowledge of the archeological discoveries of Northern Africa, Western Asia and Europe, the author paints a clear and entrancing picture of the rise of civilization. The story is not a chronological account of the succession of rulers or dynasties of any people or of their wars or conquests. It is rather a discussion of great discoveries that, directly and indirectly through tens of thousands of years from Paleolithic days down to modern times, have given rise to present civilizations.

A preliminary chapter on "Human and Natural History" presents reasons for approaching early human history in much the same spirit as one would investigate the evolution of lower animals; and this is followed by a general description of the elements of cultural progress. A chapter entitled "Time Scales" rolls back the curtain of archeological and geological history for nearly half a million years and outlines the measurements of time during the flow and ebb of successive sheets of ice of the Pleistocene.

In "Food Gatherers" the author shows how the problem of obtaining food and the discovery of fire started man on his long way toward civilization and the conquest of the world. He traces the story through many lands as it is revealed by the remains of bones and stone implements and utensils left at the sites of camps and cave dwellings. These advances led to the Neolithic period and revolution, which was followed by the ages in which pottery and bronze came into use, and this progress, in turn, paved the way for the rise of great centers of culture and power, such as those which flourished for several millennia along the banks of the Tigris and Euphrates rivers and in the valley of the Nile. The illustrations of the forces which led to the developments of these and other civilizations are extraordinarily abundant and apt.

To-day a disturbed world is floundering in uncertainty, vainly trying to understand the present and apprehensive of the future. The author's evident purpose is to give a better perspective of man and his problems, and he has eminently succeeded.

F. R. M.

[1] *Man Makes Himself.* By V. Gordon Childe. $2.50. 275 pp. Oxford University Press. 1939.

Capt. Wilkes

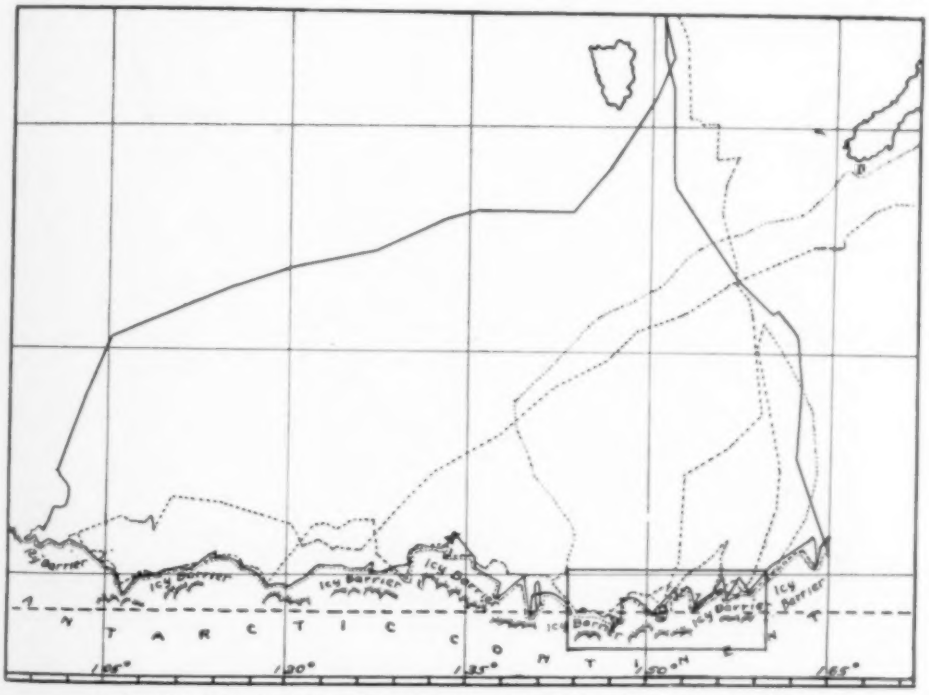
THE PROGRESS OF SCIENCE

CENTENARY CELEBRATION OF THE WILKES EXPLORING EXPEDITION

In the years 1838–1842 a great United States Exploring Expedition, the first to enter the Antarctic region, made extended cartographic and scientific researches within the Pacific area and the then unknown Antarctic region to the south of it. For the extent and the importance of its discoveries, the distinction of its corps of scientists and the volume and authority of its published reports, this expedition bears favorable comparison with the greatest exploring expeditions sent out by the European nations. It might be considered to mark the coming of age of American science.

The American expedition set sail with a squadron of six naval vessels; it was commanded throughout by Lieutenant (afterwards Rear Admiral) Charles Wilkes, and it has generally been referred to as the "Wilkes Exploring Expedition." During January and February of 1840 Wilkes discovered a new coast of the Antarctic fifteen hundred miles in extent, which for the first time proved the Antarctic land to be a continent; and this extended coast, which lies to the south of Australia, is generally shown upon the maps as Wilkes Land.

The perilous cruise of Wilkes along



A SMALL-SCALE MAP OF WILKES' CRUISE FROM HIS REPORT

THE SCALLOP PATTERNS ARE HIS LANDFALLS, SEEN BEHIND THE ICY BARRIER WHICH PREVENTED A NEARER APPROACH.

the Antarctic coast was concluded on February 23, 1840, and its centenary was celebrated by a special meeting of the American Philosophical Society held at its hall in Philadelphia on February 23 and 24, 1940. The program of the meeting covered the activities of the Wilkes Expedition, and it included in addition a symposium on American Polar Exploration, both Antarctic and Arctic. The speakers were distinguished scientists, explorers and government bureau chiefs, particularly from the Navy Department to which Wilkes belonged and under the auspices of which the expedition sailed.

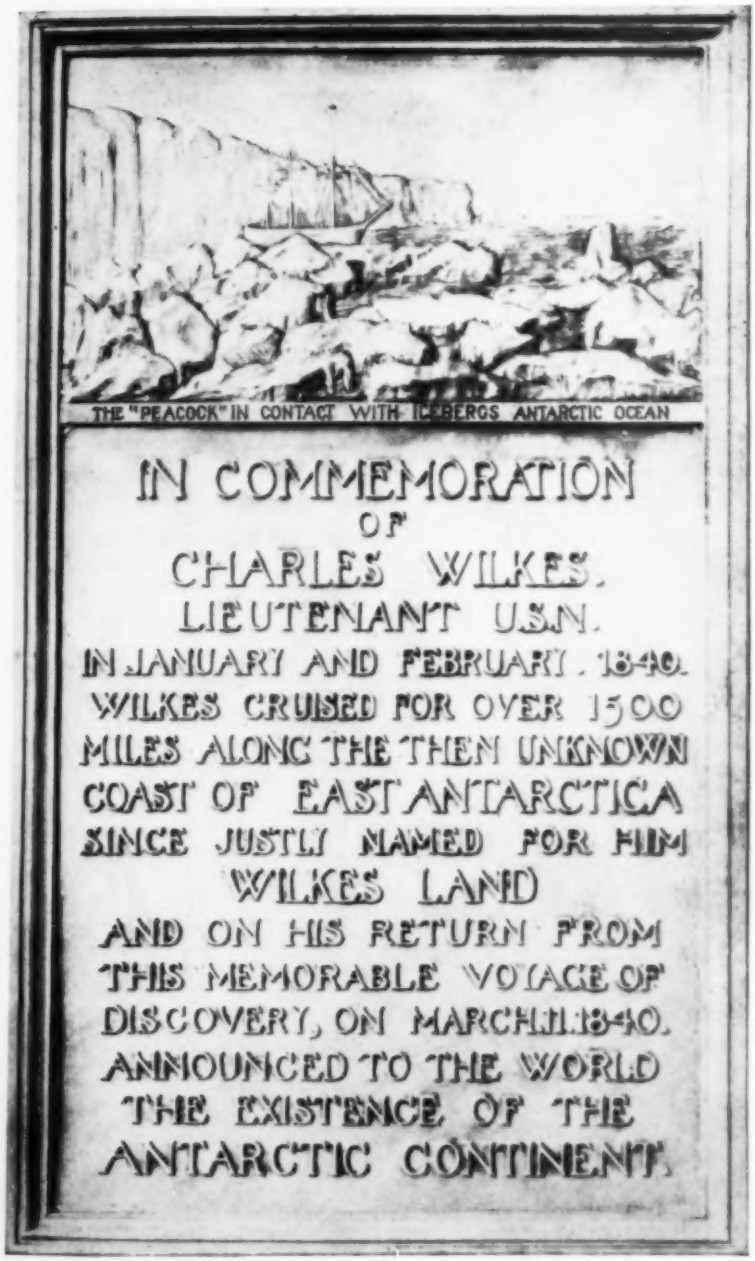
As the Centenary of the First United States Exploring Expedition was thus being signalized, the Second United States Expedition commanded by Admiral Byrd was already in the Antarctic, and the centenary synchronized closely with Byrd's great discovery of new Antarctic land stretching between 96° and 148° west longitude within an absolutely unknown coast which had defied all attempts to approach it. This important Antarctic discovery—the most notable in many years—lies outside the hinterland which was discovered by Lincoln Ellsworth in 1935, and it has nearly completed the unveiling of the Antarctic coasts.

In fixing the program for the researches of the Wilkes Expedition the American Philosophical Society played an important part; and this relation of the society to the expedition was covered in an opening address by Dr. E. G. Conklin, vice-president and executive officer of the society. The purpose, equipment and personnel of the expedition were treated by Captain G. S. Bryan, hydrographer of the Navy Department.

Wilkes was scientist as well as naval officer, and the final reports of the expedition on meteorology and on terrestrial magnetism and gravity were written by him. The volume on physics, which covered magnetism and gravity, though largely printed, had not been published when Congress stopped the appropriations with several volumes still unfinished. The expedition's accomplishments along these lines were treated by Dr. F. W. Reichelderfer, chief of the United States Weather Bureau.

The most distinguished of the scientific corps on the Wilkes Expedition was James Dwight Dana, who wrote the great volumes of reports on zoophytes, Crustacea and geology. While on the expedition, and quite independent of Darwin, Dana evolved the theory of subsidence for the origin of coral reefs and atolls, now the so-called Darwin-Dana theory. He also made a classical study

MAP OF WILKES LAND WITH ITS DIFFERENT COASTS REPRESENTED



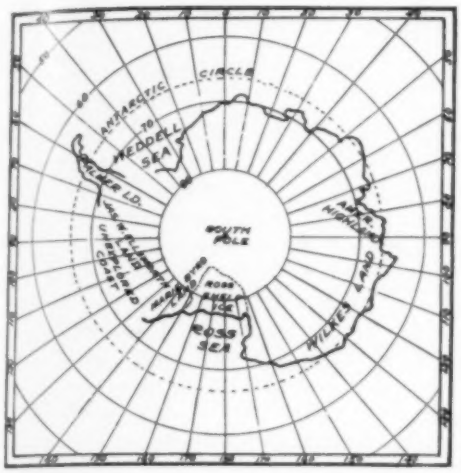
THE WILKES COMMEMORATIVE TABLET
AT THE ROOMS OF THE AMERICAN GEOGRAPHICAL SOCIETY IN NEW YORK CITY (NEGATIVE).

of the volcanoes of the Hawaiian Islands. Professor John E. Hoffmeister discussed these important researches, Professor Henry W. Fowler treated the fishes collected by the expedition, and Professor Harley H. Bartlett the published reports of the other scientists, including two volumes by the great botanist, Asa Gray. The discovery of Wilkes Land was treated by William H. Hobbs, and the surveys within the Pacific area by Mary E. Cooley, of Mount Holyoke College, who for a number of years has been preparing a biography of Wilkes which is now ready for publication.

The Wilkes Centenary was largely covered in the session of Friday morning. The afternoon session of that day was devoted to American Antarctic Exploration earlier and later than that of Wilkes. Palmer, who first discovered Antarctic Land, was treated by Colonel Lawrence Martin, chief of the Division of Maps of the Library of Congress, who recently recovered Palmer's log of the *Hero*. Captain Harold Saunders, U.S.N., discussed the South Pole flight of Admiral Byrd and his exploration of Marie Byrd Land, and Dr. W. L. G. Joerg, of the National Archives, the demonstration of the peninsular nature of Palmer Land through Ellsworth's flight of 1935. Professor Earle B. Perkins, of the Second Byrd Antarctic Expedition, treated the animal life of the Antarctic with the aid of moving pictures, and in an illustrated evening lecture Professor Laurence M. Gould, second-in-command of the First Byrd Expedition, the glaciers of the Antarctic.

The Saturday morning session, which was presided over by President Bowman, of the Johns Hopkins University, was devoted to America in the Arctic. A group of Arctic explorers treated the outstanding discoveries in that region,

THE FLAGSHIP, VINCENNES, AMONG THE ICEBERGS
SKETCHED BY CHARLES WILKES ON THE ANTARCTIC EXPEDITION, JANUARY 23, 1840.



ANTARCTIC CONTINENT IN 1939

SHOWING AMERICAN DISCOVERIES. THE IMPORTANT DISCOVERIES BY ADMIRAL BYRD DURING FEBRUARY, 1940, ARE IN THE AREA MARKED "UNEXPLORED COAST."

these speakers including Ekblaw, of the McMillan Expedition; Lee, who was Peary's companion on the crossing of Greenland in 1895; Stefansson and Captain Bob Bartlett. General Brainard, sole survivor of the Greely Expedition and now eighty-four years of age, was to have treated the Greely Expedition and the Farthest North of Lockwood and Brainard, but an attack of influenza prevented his attendance. Commander Ellsburgh, U.S.N.R., discussed "The Drift of the *Jeannette* in the Arctic Sea." Captain Bartlett spoke on the "Extended Exploration of Arctic Lands by Peary," which culminated in the attainment of the North Pole in 1909.

The papers presented at the centenary are to be published in a special centenary volume of the *Proceedings* of the society.

WILLIAM H. HOBBS

NATIONAL ZOOLOGICAL PARK EXPEDITION TO LIBERIA

THROUGH the generosity of Harvey Firestone, an expedition has been arranged for the purpose of penetrating the jungles of Liberia to collect wild animals. This expedition, which I have the honor to head, sailed from New York on February 14 on the S.S. *West Kebar*, and by the time this article is printed, will be in Liberia, to stay from three to five months.

The Firestones have long been interested in the national zoo, the late Harvey S. Firestone having presented a pygmy hippopotamus to it about 13 years ago. Harvey S. Firestone, Jr., gave the zoo a Liberian potto, an unusual animal about the size of a kitten; and other animals have been sent to us from the Firestone plantations from time to time.

On a trip of this kind one can never tell what one is going to get; the results are absolutely unprophesiable. Since there is hardly anything at all in the Zoological Park or the National Museum from Liberia, anything we get will be valuable to one or the other of these institutions. I have received innumerable letters from persons who desire to obtain animals for experiment, such as birds for anatomical studies, land or fresh-water shrimp, etc. I expect to find many species of animals, birds and reptiles which have never been taken into captivity, as well as other species which are rare in this country.

There are over 100 different kinds of animals in Liberia, many of them distinct from those in other parts of Africa. The pygmy hippopotamus, as far as I know, is found only in Liberia, although some travelers have reported that it occurs also in the next colony, Sierra Leone. Liberia lacks, however, a lot of the animals found in other parts of Africa, such as the giraffe, hippopotamus and rhinoceros. This absence is, however, made up by the presence of other animals. Liberia has never been an animal-

hunting country like the other countries of Africa.

Among the animals which I am particularly anxious to bring back alive are pygmy elephants, pygmy hippopotamuses, red bush cows, zebra antelopes, harnessed antelopes, bongos, flying squirrels and a number of species of cats, such as the West African forest leopard, the golden cat, as well as the fine-spotted serval and the blue serval—large wild cats having long legs and large untufted ears. We shall also seek the chevrotain, or water deer, which stands about 12 inches high at the shoulder and lives in the marshes.

Brilliant and unusually beautiful birds are to be found in Liberia, including the Tourocou, with unwashable feathers which hold their colors, and kingfishers. I want, too, to bring back such birds as hornbills, sunbirds, lovebirds, barbets, black and white crows and interesting storks and cranes.

There are a number of reptiles in Liberia: the subterranean python, two big vipers (the gaboon and rhinoceros viper) and several kinds of cobras. Chameleons are always an exciting catch, but they have a difficult time surviving the trip home. An interesting box-turtle, with a hinge in the back of its shell, land snails six inches long, many insects and waters full of fish help present an interesting outlook for the trip. I am taking seines in the hope of catching seldom-seen fish—a few of which I may be successful in getting all the way back home. I hope to obtain a complete collection of the fauna.

Accompanying me on this trip are Mrs. Mann, who is also familiar with wild animals, Ralph B. Norris and Roy Jennier, animal keepers at the national zoo.

Courtesy Acme Newspictures

TRACING THE ROUTE OF THE SMITHSONIAN EXPEDITION INTO AFRICA

DR. CHARLES G. ABBOT, SECRETARY OF THE SMITHSONIAN INSTITUTION; HARVEY S. FIRESTONE, JR., SPONSOR OF THE EXPEDITION; DR. WILLIAM M. MANN AND MRS. MANN.

Our equipment includes ready-made cages which telescope within each other, the last cage containing traps and bird seed. Concentrated cod-liver oils and powdered milk are necessary for baby animals, and even Mellin's baby food and honey for certain little birds. We carry a motion picture camera in hopes of getting good pictures of the animals as well as of the natives.

Monrovia, the capital of Liberia, is our landing place, with headquarters at the Harvey Firestone plantation. Perhaps it will be possible to establish a little national zoo here, as we did in East Africa and India.

While I have permits from the government giving me full authority to go out, take these animals and bring them home, it is not quite so easy as that sounds, because the animals can not read the permits and do not always offer full cooperation.

WILLIAM M. MANN,
Director
NATIONAL ZOOLOGICAL PARK

IMPORTANCE OF GRASSLAND RESERVES

AN illustrated article by Dr. Victor C. Cahalane, entitled "A Proposed Great Plains National Monument," describing a typical grassland region, will be printed in one of the forthcoming issues of THE SCIENTIFIC MONTHLY.

It is estimated that about 40 per cent. of the area of the United States represents original climatic grassland. It is likely that our dependence upon the grassland areas of the world will become greater instead of less as time goes on. Concerning their fundamental economic importance to mankind there can be no question.

This circumstance has tended to accelerate their exploitation, at the same time that it brings into sharp relief our need to understand them better than we do. Because good grassland is richly productive when first exploited, it has passed through a cycle of mining and destruction quite comparable to that suffered by the virgin forest. One who is not trained to distinguish changes in vegetation structure or floristic composition can not realize this as readily as he can understand the meaning of cut-over or burned-over forest land. To-day it is increasingly difficult to find areas giving an adequate picture of original grassland communities. To such an extent is this true that there are still to be found sharp differences of opinion regarding the proper nomenclature of some of the grassland communities.

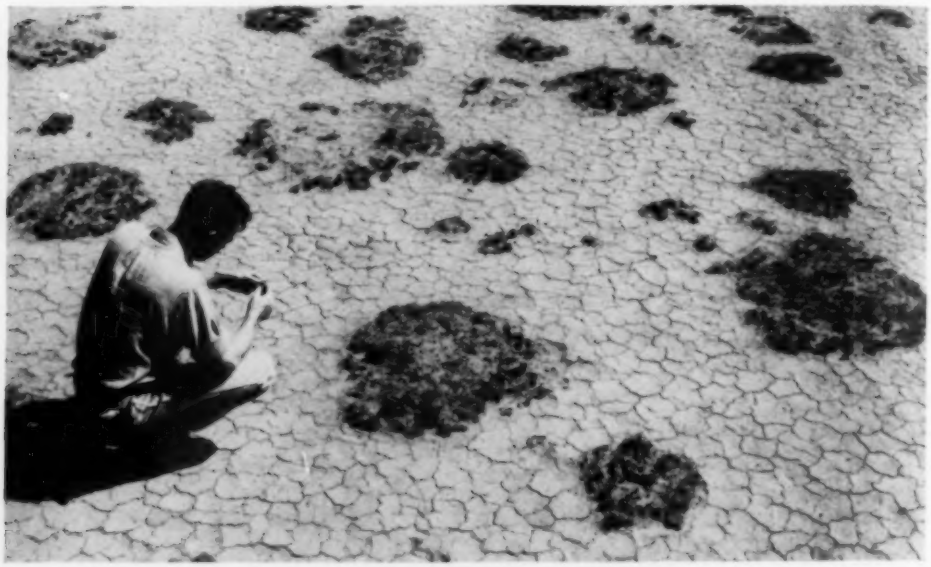
What is true of the vegetation is of course even more true of those other constituents of the grassland communities—their native animals. In the opinion of the animal ecologists who have been advising the National Research Council, it is necessary to have undisturbed areas of considerable extent, suitably buffered by additional natural areas, in order to achieve anything like the necessary restoration of the natural plant and animal interrelationship.

The layman might perhaps infer that an enterprise of this kind is largely sentimental or of such remote practical import as to represent self-indulgence for interested scientists. That such an enterprise would have many intangible values is not to be questioned, but in addition results that are direct, important and practical may be expected to follow the establishment and study of extensive natural grassland areas.

On some continents, once-productive grassland regions will no longer support human communities. There is ample evidence that this could happen in North America. If we are to forestall

WIND EROSION NEAR LITTLE COLORADO RIVER

SHOWING ITS EFFECT UPON VEGETATION. THE WIND EDDIES AROUND THE HUMMOCKS AND THE ROOTS HAVE BECOME EXPOSED AND SAND IS BURYING THE STRUGGLING GRASS. IN 1857 BEALE DESCRIBED IT AS BEING "COVERED IN ABUNDANT AND EXCELLENT GRAMMA AND BUNCH GRASS."



BARREN LAND NEAR WINSLOW, ARIZONA

BROUGHT ABOUT BY OVER-GRAZING AND ERODING WINDS. BEALE REMARKED IN 1857 THAT "FOR STOCK OF ALL KINDS I SHOULD SAY THAT A BETTER COUNTRY IS NOT WITHIN THE UNITED STATES."

WASTED LAND IN NEW MEXICO

THE GRASS HAS DISAPPEARED, AND IN ITS PLACE HAS COME UNPALATABLE SNAKEWEED. SHEET AND GULLY EROSION ARE AT WORK. EIGHTY-ONE YEARS EARLIER BEALE WROTE THAT IT WAS "A GRASSY VEGA OF ABOUT ONE HUNDRED AND SIXTY ACRES, WHERE THE WATER AND GRASS ARE GOOD AND TIMBER ABUNDANT—CEDAR AND PINE."

FERTILE LANDS NEAR FLAGSTAFF, ARIZONA

VERDANT AND PRODUCTIVE LAND CONSERVED THROUGH CONTROLLED GRAZING

such an outcome we can expect to do so only by energetic measures based upon a realistic knowledge of the grassland environment in all its aspects. It is well established that the best integration of the many complex factors in an environment is represented by the natural living communities which it has supported. Grassland communities, moreover, not only express their environment but are the agency which has been responsible for its present capacity to support human communities. These natural communities have steadfastly elaborated materials and transformed solar energy. This has resulted in the relationship known as soil, which, with water, is so largely the measure of the capacity of an environment to support life.

The net result of human occupation to date has been to arrest and reverse these constructive processes. Permanent human occupation demands the ability to create a constructive relationship analogous to that represented by the work of the natural communities. Until we know how to do this and can get it into operation, there is no type of scientific investigation of more fundamental importance to our continued use of the grassland than a study of how the natural communities do the thing which we, as yet, can not do.

PAUL B. SEARS

ENDOCRINE GLANDS AND THEIR DISORDERS

THE Twelfth Annual Graduate Fortnight of the New York Academy of Medicine, held from October 23 to November 3, 1939, was entitled "The Endocrine Glands and Their Disorders." The purpose of the Graduate Fortnight is to instruct the family doctor in the latest developments of scientific medicine and to enable him to learn their application to his practice from the leading experts of the nation. More than a thousand physicians participated in the lectures, round-table discussions and exhibits.

The general plan of the fortnight was as follows: Each evening one or more experts reviewed the present state of our knowledge of one of the endocrine glands. On four mornings round-table discussions were held in which an opportunity was given the doctors to have their questions answered by the lecturer or another expert. As a background for all this the rooms and halls of the beautiful Academy of Medicine building were converted into exhibit halls, where photographs, charts, x-ray pictures, anatomical specimens and apparatus were shown.

The opening lecture was delivered by Dr. H. M. Evans, who sketched the historical development of our knowledge of the endocrine glands.

Dr. J. B. Collip, known to the world for his work in the isolation of insulin, reviewed the functions of the pituitary gland. This gland has been called the leader of the glandular symphony because it is the master gland and controls the functions of almost all the other glands. Dr. Leo M. Davidoff presented the clinical states that result from diseases of this master gland. An increase in function may cause excessive growth and the production of giants, while decreased function of this organ is responsible for the tiny dwarfs and "living skeletons" that amuse us in the circus or the theaters.

Dr. Leopold Lichwitz discussed the diseases due to simultaneous involvement of the pituitary gland and its nervous connections in the base of the brain. These include the most marked cases of obesity and an unusual disturbance known as diabetes insipidus in which an afflicted

person may drink as much as 56 pints of fluid in a single day.

Dr. J. H. Means, H. T. Hyman and Frank H. Lahey discussed disorders of the thyroid gland. Diminished function of the gland results in obesity, dry skin and hair, as well as mental and physical torpor. Overfunction of the thyroid causes persons to be abnormally alert and active, very nervous and often to have a goiter and "pop-eyes."

Dr. Robert Loeb outlined our knowledge of Addison's disease. This malady, due to destruction of both adrenal glands by tuberculosis or some other disease, results in profound weakness, intestinal disturbances and a most striking bronzing of the skin of the sufferer, who may become as black as a Negro.

Dr. Solomon Silver presented a series of "bearded ladies" who are known to the lay public only as circus attractions, but afford the endocrinologist some of his most baffling problems. He pointed out that not one, but several, glandular anomalies can bring about this sad fate for the feminine victim.

Five investigators detailed the effect in both sexes of the sudden or gradual loss of function of the sex glands. In women this brings about the well-known and often troublesome period of the "change of life." The very annoying physical and mental symptoms of this transition can now be effectively controlled by the use of ovarian products to replace the function of the failing ovary. In the male, experiments indicate a restoration of sexual vigor by the use of a preparation that replaces the function of aging or absent testes.

It was the opinion of those who listened to these ten evenings of lectures that a comprehensive and instructive survey of the field of the endocrine glands had been offered to practicing physicians and that in doing it the New York Academy of Medicine had rendered a valuable service to them.

SOLOMON SILVER, M.D.

DISPELLING FOG

FOG is the most serious menace to aviation and one of the greatest hazards to shipping. However, like everything else, it is not an unmixed evil—it clears the air of dust and microorganisms. The problem is to overcome its ill effects where it is disadvantageous and to welcome its benefits.

As Dr. Karl T. Compton, president of the Massachusetts Institute of Technology, has recently announced, the scientists of M. I. T., in cooperation with those of other institutions, have been investigating the properties of fogs for the purpose of overcoming their disadvantages. Instead of looking for some magical method of dispelling fogs, they first investigated their properties. They found that in an average fog on the coast of New England the amount of water in the droplets of which fogs are composed is only about one sixtieth of that which the air contains as invisible vapor. In a space 1,000 yards long, 100 feet high and 200 feet wide, which would have to be cleared for safe landing of an airplane by visual means at the time of an ordinary fog, there is about 30 tons of water, 1,000 pounds of which produces fog. Evidently no simple and inexpensive method can dispose of so much water.

The scientists found that there is no chance that any light radiations from the invisible ultra-violet to the equally invisible infra-red, can penetrate fogs to any considerable distance. They did find, however, that very short radio waves, of the order of two centimeters in length, produce resonant electric currents in the minute fog droplets. These currents heat and evaporate the droplets, causing a hole through the fog. Unfor-

tunately, no sufficiently powerful source of such short radio waves has been made, and at the best the method would be costly.

It is well known that calcium chloride absorbs water—it is, in fact, one of the best drying agents. To make effective use of this property, a spray of concentrated solution calcium chloride was sprayed from nozzles distributed along pipe placed horizontally at a distance of 50 feet or more above the ground. As the spray fell slowly through the foggy air it took up enough water vapor to reduce its humidity below the point at which the fog droplets would evaporate. The fog vanished as if by magic, and as the breeze carried the treated air along, a clear corridor from 100 to 200 feet wide and from 50 to 100 feet in height was produced. This would be sufficient for the safe landing of planes guided by a radio beam until they entered the clear space. But to produce the clear space would cost about $5 per minute. Fortunately the means of guiding planes safely through impenetrable fogs are rapidly being improved. F. R. M.

AVERAGE USE OF MECHANICAL POWER

At various times in the history of the world a high state of civilization of a relatively small part of a people has rested on the work of slaves. As in Greece, the slaves outnumbered the free men five to one, and the ratio may have been greater in Imperial Rome when she was at the zenith of her power.

In these days civilizations depend on the use of mechanical power. The average use of mechanical energy for the whole world, advanced peoples and the primitive, adults and children, is the equivalent of about 50 man hours of labor for every day in the year. In the United States the average is more than twice as great.

Various reasons have been ascribed for the deterioration of earlier civilizations, such as moral degeneration, lack of religion, use of dictators, invasion of barbarians, political corruption, mosquitoes, exhaustion from wars, etc. May there not have been a more fundamental reason? We remember the glorious achievements of the few, forgetting the ignorance and degradation of the many. At no time was the average high. When civilizations failed, probably what really happened was that the few who glistened for a moment on the crest of the waves were swallowed up in the level of the deep above which they temporarily rose. More literally, the fundamental biological processes relentlessly pursued their way and the many who served the few were the parents of their successors.

Modern civilizations are essentially different from the ancient. In spite of the claims of demagogues, slaves have been banished by machines and the base of a civilization has become essentially the entire population. Consequently there are good reasons for hoping and believing that, even though there should be disorders and wars, there is no serious danger of another sinking of humanity into chaos and barbarism. Machines carry no genes that may corrupt the stream of life of our successors.

F. R. M.